Author: Jan Walleckec
Category: Trustee Memos
Date: April 23, 2020

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> "I feel that we are on the threshold of a new order where people will be seeking enlightened change. ... This will all come about with the infusion of spirituality into science. The Foundation's eventual intent is to integrate the scientific process with spiritual mindedness … A fundamental key to all this is to conduct this search with a proper line of scientific investigation."

In the last ten years, Fetzer Franklin led breakthroughs in the following areas:

1. Relational Reality – the concept of the interconnection of all things at the quantum level now exists within mainstream physics academies in the world.
2. Metascience – the scientific study of the scientific method is a high priority for most major funding institutions in the world.
3. Advanced Protocols to study anomalous phenomena are becoming accepted. This could present an opportunity to advance mainstream investigation of extreme possibilities in the area of psi and subtle energy research. Psi, energy medicine, and subtle energy were dominant interests of John Fetzer. These revolutionary advanced protocols could help discern real effects from false positive effects which would catalyze substantial interest in these fields.

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PUBLICATIONS

A FEEL FOR NUMBERS: THE CHANGING ROLE OF GESTURE IN MANIPULATING THE MENTAL REPRESENTATION OF AN ABACUS AMONG CHILDREN AT DIFFERENT SKILL LEVELS

Frontiers in Psychology 9

Abacus mental arithmetic involves the skilled acquisition of a set of gestures representing mathematical algorithms to properly manipulate an imaginary abacus. The present study examined how the beneficial effect of abacus co-thought gestures varied at different skill and problem difficulty levels. We compared the mental arithmetic performance of 6- to 8-year-old beginning (N = 57), intermediate (N = 65), and advanced (N = 54) learners under three conditions: a physical abacus, hands-free (spontaneous gesture) mental arithmetic, and hands-restricted mental arithmetic. We adopted a mixed-subject design, with level of difficulty and skill level as the within-subject independent variables and condition as the between-subject independent variable.

Our results showed a clear contrast in calculation performance and gesture accuracy among learners at different skill levels. Learners first mastered how to calculate using a physical abacus and later benefitted from using abacus gestures to aid mental arithmetic. Hand movement and gesture accuracy indicated that the beneficial effect of gestures may be related to motor learning. Beginners were proficient with a physical abacus, but performed poorly and had low gesture accuracy during mental arithmetic.

Intermediates relied on gestures to do mental arithmetic and had accurate hand movements, but performed more poorly when restricted from gesturing. Advanced learners could perform mental arithmetic with accurate gestures and scored just as well without gesturing. These findings suggest that for intermediate and advanced learners, motor-spatial representation through abacus co-thought gestures may complement visual-spatial representation of a mental abacus to reduce working memory load.

The article was published in: Frontiers in Psychology 9: 1267.

Full article

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2018

FIELD OF SCIENCE
Consciousness

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PUBLICATIONS

A LENIENT CAUSAL ARROW OF TIME?

Entropy 20(4)

One of the basic assumptions underlying Bell's theorem is the causal arrow of time, having to do with temporal order rather than spatial separation. Nonetheless, the physical assumptions regarding causality are seldom studied in this context, and often even go unmentioned, in stark contrast with the many different possible locality conditions which have been studied and elaborated upon. In the present work, some retrocausal toy-models which reproduce the predictions of quantum mechanics for Bell-type correlations are reviewed.

It is pointed out that a certain toy-model which is ostensibly superdeterministic—based on denying the free-variable status of some of quantum mechanics' input parameters—actually contains within it a complete retrocausal toy-model. Occam's razor thus indicates that the superdeterministic point of view is superfluous. A challenge is to generalize the retrocausal toy-models to a full theory—a reformulation of quantum mechanics—in which the standard causal arrow of time would be replaced by a more lenient one: an arrow of time applicable only to macroscopically-available information. In discussing such a reformulation, one finds that many of the perplexing features of quantum mechanics could arise naturally, especially in the context of stochastic theories.

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Full article

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FIELD OF SCIENCE
Physics

Back to Publications

PUBLICATIONS

A METHOD FOR MEASURING THE REAL PART OF THE WEAK VALUE OF SPIN USING NON-ZERO REST MASS PARTICLES

arXiv

A method for measuring the real part of the weak (local) value of spin is presented using a variant on the original Stern-Gerlach apparatus. The experiment utilises metastable helium in the 23S1 state. A full simulation using the impulsive approximation has been carried out and it predicts a displacement of the beam by $\Delta w = 17 - 33$ μm. This is on the limit of our detector resolution and we will discuss ways of increasing Δw. The simulation also indicates how we might observe the imaginary part of the weak value.
The article was published in: arXiv

Full article

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FIELD OF SCIENCE
Physics

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PUBLICATIONS

A METHOD FOR MEASURING THE WEAK VALUE OF SPIN FOR METASTABLE ATOMS

Entropy 20(8)

A method for measuring the weak value of spin for atoms is proposed using a variant of the original Stern-Gerlach apparatus. A full simulation of an experiment for observing the real part of the weak value using the impulsive approximation has been carried out. Our predictions show a displacement of the beam of helium atoms in the metastable 2^3S_1 state, Δ_W, that is within the resolution of conventional microchannel plate detectors indicating that this type of experiment is feasible.

Our analysis also determines the experimental parameters that will give an accurate determination of the weak value of spin. Preliminary experimental results are shown for helium, neon and argon in the 2^3S_1 and $^3P_2$ metastable states, respectively.

The article was published in: Entropy 20(8): 566.

Full article

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FIELD OF SCIENCE
Physics

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PUBLICATIONS

A NEW CLASS OF RETROCAUSAL MODELS

Entropy 20(6)

Globally-constrained classical fields provide a unexplored framework for modeling quantum phenomena, including apparent particle-like behavior. By allowing controllable constraints on unknown past fields, these models are retrocausal but not retro-signaling, respecting the conventional block universe viewpoint of classical spacetime. Several example models are developed that resolve the most essential problems with using classical electromagnetic fields to explain single-photon phenomena.

These models share some similarities with Stochastic Electrodynamics, but without the infinite background energy problem, and with a clear path to explaining entanglement phenomena. Intriguingly, the average intermediate field intensities share a surprising connection with quantum "weak values", even in the single-photon limit. This new class of models is hoped to guide further research into spacetime-based accounts of weak values, entanglement, and other quantum phenomena.

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Full article

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FIELD OF SCIENCE
Physics

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PUBLICATIONS

A QUANTUM SPECTROMETER FOR ARBITRARY NOISE

arXiv

We present a technique for recovering the spectrum of a non-Markovian bosonic bath and/or non- Markovian noises coupled to an harmonic oscillator. The treatment is valid under the conditions that the environment is large and hot compared to the oscillator, and that its temporal autocorrelation functions are symmetric with respect to time translation and reflection – criteria which we consider fairly minimal.

We model a demonstration of the technique as deployed in the experimental scenario of a nanosphere levitated in a Paul trap, and show that it can effectively probe the spectrum of an electric field noise source from 10 − 10 Hz with a high degree of accuracy (proportional to the reciprocal of the measurement time) owing to its unusually low noise floor. This technique may be deployed in quantum sensing, metrology, computing, and in experimental probes of foundational questions.

The article was published in: *arXiv preprint arXiv:1901.10445*.

Full article

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YEAR
2019

FIELD OF SCIENCE
Physics

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PUBLICATIONS

A THIRD MEASURE-METASTABLE STATE IN THE DYNAMICS OF SPONTANEOUS SHAPE CHANGE IN HEALTHY HUMAN'S WHITE CELLS

PLoS Computational Biology 7(4)

Info

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YEAR
2011

FIELD OF SCIENCE
Biology

Human polymorphonuclear leucocytes, PMN, are highly motile cells with average 12-15 μm diameters and prominent, loboid nuclei. They are produced in the bone marrow, are essential for host defense, and are the most populous of white blood cell types. PMN also participate in acute and chronic inflammatory processes, in the regulation of the immune response, in angiogenesis, and interact with tumors. To accommodate these varied functions, their behavior is adaptive, but still definable in terms of a set of behavioral states. PMN morphodynamics have generally involved a non-equilibrium stationary, spheroid Idling state that transitions to an activated, ellipsoid translocating state in response to chemical signals.

These two behavioral shape-states, spheroid and ellipsoid, are generally recognized as making up the vocabulary of a healthy PMN. A third, "random" state has occasionally been reported as associated with disease states. I have observed this third, Treadmilling state, in PMN from healthy subjects, the cells demonstrating metastable dynamical behaviors known to anticipate phase transitions in mathematical, physical, and biological systems. For this study, human PMN were microscopically imaged and analyzed as single living cells.

I used a microscope with a novel high aperture, cardioid annular condenser with better than 100 nanometer resolution of simultaneous, mixed dark field and intrinsic fluorescent images to record shape changes in 189 living PMNs. Relative radial roundness, R(t), served as a computable order parameter. Comparison of R(t) series of 10 cells in the Idling and 10 in the Treadmilling state reveals the robustness of the "random" appearing Treadmilling state, and the emergence of behaviors observed in the neighborhood of global state transitions, including increased correlation length and variance (divergence), sudden jumps, mixed phases, bimodality, power spectral scaling and temporal slowing. Wavelet transformation of an R(t) series of an Idling to Treadmilling state change, demonstrated behaviors concomitant with the observed transition.

The article was first published in: PLoS Computational Biology 7(4): e1001117.

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PUBLICATIONS

AGENT INACCESSIBILITY AS A FUNDAMENTAL PRINCIPLE IN QUANTUM MECHANICS: OBJECTIVE UNPREDICTABILITY AND FORMAL UNCOMPUTABILITY

Entropy 21(1)

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FIELD OF SCIENCE
Physics

The inaccessibility to the experimenter agent of the complete quantum state is well-known. However, decisive answers are still missing for the following question: What underpins and governs the physics of agent inaccessibility? Specifically, how does nature prevent the agent from accessing, predicting, and controlling, individual quantum measurement outcomes?

The orthodox interpretation of quantum mechanics employs the metaphysical assumption of indeterminism—'intrinsic randomness'—as an axiomatic, in-principle limit on agent-quantum access. By contrast, ontological and deterministic interpretations of quantum mechanics typically adopt an operational, in-practice limit on agent access and knowledge—'effective ignorance'.

The present work considers a third option—'objective ignorance': an in-principle limit for ontological quantum mechanics based upon self-referential dynamics, including undecidable dynamics and dynamical chaos, employing uncomputability as a formal limit. Given a typical quantum random sequence, no formal proof is available for the truth of quantum indeterminism, whereas a formal proof for the uncomputability of the quantum random sequence—as a fundamental limit on agent access ensuring objective unpredictability—is a plausible option. This forms the basis of the present proposal for an agent-inaccessibility principle in quantum mechanics.

The article was published in: Entropy 21(1): 4.

Full article

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PUBLICATIONS

AN ONTOLOGY OF NATURE WITH LOCAL CAUSALITY, PARALLEL LIVES, AND MANY RELATIVE WORLDS

Foundations of Physics 48(12)

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YEAR
2018

FIELD OF SCIENCE
Physics

Parallel lives (PL) is an ontological model of nature in which quantum mechanics and special relativity are unified in a single universe with a single space-time. Point-like objects called lives are the only fundamental objects in this space-time, and they propagate at or below c, and interact with one another only locally at point-like events in space-time, very much like classical point particles. Lives are not alive in any sense, nor do they possess consciousness or any agency to make decisions—they are simply point objects which encode memory at events in space-time. The only causes and effects in the universe occur when lives meet locally, and thus the causal structure of interaction events in space-time is Lorentz invariant.

Each life traces a continuous world-line through space-time, and experiences its own relative world, fully defined by the outcomes of past events along its world-line (never superpositions), which are encoded in its external memory. A quantum field comprises a continuum of lives throughout space-time, and familiar physical systems like particles each comprise a sub-continuum of the lives of the field. Each life carries a hidden internal memory containing a local relative wavefunction, which is a local piece of a pure universal wavefunction, but it is the relative wavefunctions in the local memories throughout space-time which are physically real in PL, and not the universal wavefunction in configuration space.

Furthermore, while the universal wavefunction tracks the average behavior of the lives of a system, it fails to track their individual dynamics and trajectories. There is always a preferred separable basis, and for an irreducible physical system, each orthogonal term in this basis is a different relative world—each containing some fraction of the lives of the system. The relative wavefunctions in the lives' internal memories govern which lives of different systems can meet during future local interactions, and thereby enforce entanglement correlations—including Bell inequality violations. These, and many other details, are explored here, but several aspects of this framework are not yet fleshed out, and work is ongoing.

The article was published in: Foundations of Physics 48(12): 1698-1730.

Full article

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PUBLICATIONS

ARBITRARY FAIRNESS IN REWARDS AND PUNISHMENTS

PsyArXiv

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FIELD OF SCIENCE
Consciousness

People have a strong preference for fairness. For many, fairness means equal rewards and punishments for equal efforts and offences. However, this belief does not specify the units in which equality should be expressed. We show that people generally fail to take the interchangeability of units into account when judging and assigning fair punishments and rewards. As a consequence, judgments about and distributions of resources are strongly influenced by arbitrary decisions about which unit to express them in.

For example, if points represent different monetary values for different recipients, people attempt to distribute money equally if money is salient, but attempt to distribute points equally if points are salient. Because beliefs about fairness are a fundamental principle in many domains, the implications of these findings are broad. Essentially any distribution of outcomes can be made to appear more or less fair by changing the units these outcomes are expressed in.

The article was published in: PsyArXiv. September 18.

Full article

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PUBLICATIONS

ATOM-OPTICS KNIFE EDGE: MEASURING NARROW MOMENTUM DISTRIBUTIONS

Physical Review

By employing the equivalent of a knife-edge measurement for matter-waves, we are able to char- acterize ultra-low momentum widths. We measure a momentum width corresponding to an effective temperature of 0.9 ± 0.2 nK, limited only by our cooling performance. To achieve similar resolution using standard methods would require hundreds of milliseconds of expansion or Bragg beams with tens of Hz frequency stability.

Furthermore, we show evidence of tunneling in a 1D system when the "knife-edge" barrier is spatially thin. This method is a useful tool for atomic interferometry and for other areas in cold-atom physics where a robust and precise technique for characterizing the momentum distribution is crucial.

The article was published in: Physical Review A, Volume 98, Issue 2.

Full article

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YEAR
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FIELD OF SCIENCE
Physics

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PUBLICATIONS

AUTOMATED GENERATION OF KOCHEN-SPECKER SETS

Scientific reports 9(1)

Quantum contextuality turns out to be a necessary resource for universal quantum computation and also has applications in quantum communication. Thus it becomes important to generate contextual sets of arbitrary structure and complexity to enable a variety of implementations. In recent years, such generation has been done for contextual sets known as Kochen-Specker sets. Up to now, two approaches have been used for massive generation of non-isomorphic Kochen-Specker sets: exhaustive generation up to a given size and downward generation from master sets and their associated coordinatizations. Master sets were obtained earlier from serendipitous or intuitive connections with polytopes or Pauli operators, and more recently from arbitrary vector components using an algorithm that generates orthogonal vector groupings from them. However, both upward and downward generation face an inherent exponential complexity barrier. In contrast, in this paper we present methods and algorithms that we apply to downward generation that can overcome the exponential barrier in many cases of interest.
These involve tailoring and manipulating Kochen- Specker master sets obtained from a small number of simple vector components, filtered by the features of the sets we aim to obtain. Some of the classes of Kochen-Specker sets we generate contain all previously known ones, and others are completely novel. We provide examples of both kinds in 4- and 6-dim Hilbert spaces. We also give a brief introduction for a wider audience and a novice reader.

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Full article

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YEAR
2019

FIELD OF SCIENCE
Physics

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PUBLICATIONS

BACTERIA IN BLOOD FROM FIBROMYALGIA PATIENTS INCLUDE THE AQUABACTERIUM GENUS, PRODUCING METABOLITES WITH INFLAMMATORY PROPERTIES IN VITRO. RESULTS FROM A PILOT STUDY

IJCAM. 2019;12(6):232–239

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YEAR
2019

FIELD OF SCIENCE
Biology

Purpose: To evaluate bacterial presence and evidence of inflammatory metabolic activity in blood of patients with Fibromyalgia Syndrome (FMS).

Patients and methods: A human clinical pilot study involved eight FMS patients and four healthy controls. Whole blood and purified erythrocytes were cultured and examined by darkfield fluorescence microscopy and flow cytometry. DNA was subjected to amplification using polymerase chain reactions. Bioactivity of bacterial metabolites was tested on peripheral blood mononuclear cells (PBMC), cultured in the presence of metabolite fractions from FMS and healthy control erythrocyte cultures. CD69 and CD25 expression was evaluated by flow cytometry, and levels of inflammatory cytokines tested by Luminex array.

Results: Blood cultures from fibromyalgia patients revealed growth of bacteria under culture conditions involving RPMI-1640 medium, increased levels of glucose and iron, and reduced oxygen. The ex vivo expansion of bacteria through culture, combined with 16S rDNA PCR analysis of DNA isolated from whole blood and erythrocyte cultures, identified bacterial sequences derived from the Aquabacterium genus. The design of Aquabacterium-specific primers resulted in detection of Aquabacterium DNA in blood from some healthy control subjects as well, suggesting a low level of bacteria in a more quiescent state. PBMC cultured in the presence of supernatants from FMS erythrocyte cultures showed increased levels of CD69+ CD25+ lymphocytes, and increased production of the inflammatory cytokines IL-6 ($p<0.25$), IL-8 ($p<0.08$), and TNF-alpha ($p<0.01$) when compared to supernatants from erythrocyte cultures from healthy individuals. Conclusion: Bacteria from the biofilm-forming microaerophilic Gram-negative Aquabacterium genus were detected in blood from FMS patients and some healthy controls. Only bacterial cultures from FMS patients produced inflammatory metabolites, suggesting that Aquabacterium bacteria from FMS patients may express different genes than in healthy controls, potentially contributing to the chronic pain and inflammation characteristic of FMS.

Full article

This work was supported (in part) by the Fetzer Franklin Fund of the John E. Fetzer Memorial Trust.

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PUBLICATIONS

BELIEVING THERE IS NO FREE WILL CORRUPTS INTUITIVE COOPERATION

Cognition 151

Info

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2016

FIELD OF SCIENCE
Consciousness

Regardless of whether free will exists, believing that it does affects one's behavior. When an individual's belief in free will is challenged, one can become more likely to act in an uncooperative manner. The mechanism behind the relationship between one's belief in free will and behavior is still debated. The current study uses an economic contribution game under varying time constraints to elucidate whether reducing belief in free will allows one to justify negative behavior or if the effects occur at a more intuitive level of processing.

Here we show that although people are intuitively cooperative, challenging their belief in free will corrupts this behavior, leading to impulsive selfishness. If given time to think, however, people are able to override the initial inclination toward self-interest induced by discouraging a belief in free will.

The article was published in: Cognition 151: 6-9.

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PUBLICATIONS

BELL-BLOOM MAGNETOMETER LINEARIZATION BY INTENSITY MODULATION CANCELLATION

IEEE Transactions on Instrumentation and Measurement.

This paper describes a technique for enhancing the linearity of a Bell-Bloom optical magnetometer. Both the M_x and Bell-Bloom magnetometers are examined, and the characteristics of their photodetector signals are compared. It is noted that the phase signal has better linearity than the quadrature amplitude signal for a M_x magnetometer, while phase and quadrature amplitude give similar performance in Bell-Bloom.

A cancellation technique is proposed whereby the laser intensity modulation of Bell-Bloom is mitigated to improve the linearity. A cesium microfabricated atomic magnetometer in a frequency-locked-loop configuration is demonstrated, and the improved slew rate and frequency-domain linearity are shown. This linearity enhancement should prove useful for operating atomic magnetometers in interference-rich environments outside of magnetic shields.

The article was published in: *IEEE Transactions on Instrumentation and Measurement.*

Full article

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YEAR
2019

FIELD OF SCIENCE
Physics

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PUBLICATIONS

BELL'S THEOREM AND SPACETIME-BASED REFORMULATIONS OF QUANTUM MECHANICS

arXiv

In this critical review of Bell's Theorem, its implications for reformulations of quantum theory are considered. The assumptions of the theorem are set out explicitly, within a framework of mathematical models with well-defined inputs and outputs. Attention is drawn to the assumption that the mathematical quantities associated with a certain time and place can depend on past model inputs (such as preparation settings) but not on future inputs (such as measurement settings at later times). Keeping this time- asymmetric assumption leads to a substantial tension between quantum mechanics and relativity.

Relaxing it, as should be considered for such no-go theorems, opens a category of Future-Input Dependent (FID) models, for which this tension need not occur. This option (often called "retrocausal") has been repeatedly pointed out in the literature, but the exploration of explicit FID models capable of describing specific entanglement phenomena has begun only in the past decade. A brief survey of such models is included here. Unlike conventional quantum models, the FID model parameters needed to specify the state of a system do not grow exponentially with the number of entangled particles. The promise of generalizing FID models into a Lorentz-covariant account of all quantum phenomena is identified as a grand challenge.

The article wasa published in: arXiv:1906.04313

Full article

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YEAR
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FIELD OF SCIENCE
Physics

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YEAR
2019

FIELD OF SCIENCE
Physics

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PUBLICATIONS

BENCHMARKS OF NONCLASSICALITY FOR QUBIT ARRAYS

npj Quantum Information 5(1)

We present a set of practical benchmarks for N-qubit arrays that economically test the fidelity of achieving multi-qubit nonclassicality. The benchmarks are measurable correlators similar to two-qubit Bell correlators, and are derived from a particular set of geometric structures from the N-qubit Pauli group. These structures prove the Greenberger–Horne–Zeilinger (GHZ) theorem, while the derived correlators witness genuine N-partite entanglement and establish a tight lower bound on the fidelity of particular 2N stabilizer state preparations.

The correlators need only $M \leq N + 1$ distinct measurement settings, as opposed to the 2 that would normally be required to tomographically verify their associated stabilizer states. We optimize the measurements of these correlators for a physical array of qubits that can be nearest-neighbor-coupled using a circuit of controlled-Z gates with constant gate depth to form N-qubit linear cluster states. We numerically simulate the provided circuits for a realistic scenario with $N = 3, \ldots, 9$ qubits, using ranges of T1 energy relaxation times, T2 dephasing times, and controlled-Z gate-fidelities consistent with Google's 9-qubit superconducting chip. The simulations verify the tightness of the fidelity bounds and witness nonclassicality for all nine qubits, while also showing ample room for improvement in chip performance.

The article was published in: npj Quantum Information 5(1): 66.

Full article

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PUBLICATIONS

BORN'S RULE AS SIGNATURE OF A SUPERCLASSICAL CURRENT ALGEBRA

Annals of Physics 343

We present a new tool for calculating the interference patterns and particle trajectories of a double-, three- and N-slit system on the basis of an emergent sub-quantum theory developed by our group throughout the last years. The quantum itself is considered as an emergent system rep- resenting an off-equilibrium steady state oscillation maintained by a constant throughput of energy provided by a classical zero-point energy field. We introduce the concept of a "relational causality" which allows for evaluating structural interdependences of different systems levels, i.e. in our case of the relations between partial and total probability density currents, respectively.

Combined with the application of 21st century classical physics like, e.g., modern nonequilibrium thermodynamics, we thus arrive at a "superclassical" theory. Within this framework, the proposed current algebra directly leads to a new formulation of the guiding equation which is equivalent to the original one of the de Broglie-Bohm theory. By proving the absence of third order interferences in three-path systems it is shown that Born's rule is a natural consequence of our theory.

Considering the series of one-, double-, or, generally, of N -slit systems, with the first appearance of an interference term in the double slit case, we can explain the violation of Sorkin's first order sum rule, just as the validity of all higher order sum rules. Moreover, the Talbot patterns and Talbot distance for an arbitrary N -slit device can be reproduced exactly by our model without any quantum physics tool.

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Full article

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YEAR
2014

FIELD OF SCIENCE
Physics

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PUBLICATIONS

CALCIFYING NANOPARTICLES PROMOTE MINERALIZATION IN VASCULAR SMOOTH MUSCLE CELLS: IMPLICATIONS FOR ATHEROSCLEROSIS

International Journal of Nanomedicine 9

Info

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YEAR
2014

FIELD OF SCIENCE
Biology, Physics

Nano-sized complexes of calcium phosphate mineral and proteins (calcifying nanoparticles [CNPs]) serve as mineral chaperones. Thus, CNPs may be both a result and cause of soft tissue calcification processes. This study determined if CNPs could augment calcification of arterial vascular smooth muscle cells in vitro.

The study was published in: International journal of nanomedicine 9: 2689.

Full article

This work was supported (in part) by the Fetzer Franklin Fund of the John E. Fetzer Memorial Trust.

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PUBLICATIONS

CAN A METAPHOR OF PHYSICS CONTRIBUTE TO MEG NEUROSCIENCE RESEARCH? INTERMITTENT TURBULENT EDDIES IN BRAIN MAGNETIC FIELDS

Chaos, Solitons & Fractals 55

Info

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2013

FIELD OF SCIENCE
Biology, Physics

A common manifestation of nonlinear mathematical and experimental neurobiological dynamical systems in transition, intermittence, is currently being attended by concepts from physics such as turbulent eddy and the avalanche of critical systems. Do these concepts constitute an enticing poetry of dynamical universality or do these metaphors from physics generate more specific novel and relevant concepts and experiments in the neurosciences?

Using six graphics and ten measures derived from the ergodic theory of dynamical systems, we study the magnetoencephalic, MEG, records of taskless, "resting" human subjects to find consistent evidence for turbulent (chaotic) dynamics marked by intermittent turbulent eddies.

This brings up an apparent discrepancy via the juxtaposition of the superposition characteristics of magnetic fields and the non-superposition properties of turbulent flow. Treating this apparent inconsistency as an existent duality, we propose a physical model for how that might be the case. This leaves open the question: has the physical metaphor, turbulent eddy, contributed to a scientific understanding of the human resting MEG?

The article was published in. Chaos, Solitons & Fractals 55: 95-101.

Full article

This work was supported (in part) by the Fetzer Franklin Fund of the John E. Fetzer Memorial Trust.

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PUBLICATIONS

CHARACTERIZATION OF PRIMO NODES AND VESSELS BY HIGH RESOLUTION LIGHT MICROSCOPY

The Primo Vascular System, Springer

Info

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YEAR
2012

FIELD OF SCIENCE
Physics

Morphological properties of primo vascular system were characterized by a high resolution light microscopy that makes structural features with size of ~100 nm clearly visible. High visibility and advanced contrast of the smallest features in the image are due to enhancement of high spatial frequencies in the optical transfer function. We have isolated primo nodes (PN), vessels (PV), and capillaries from the surface of organs in the peritoneal cavity of rats.

These structures correspond to Bonghan corpuscle, ducts, and ductules, discovered by B.H. Kim in the early 1960s. The non-fixed samples stained with acridine orange and Bouin fixed and H&E stained slides were observed, photographed, and analyzed. The primo vessel is composed of 1–20 primo-capillaries of 3–25 μm in diameter. A thin external envelope of primo-capillary is composed of muscle-like endothelial cells with rod-shape 15–20 μm nuclei directed along the capillary axis. The primo-capillaries carry a liquid that contains granules and cell-like structures rich in nucleic acids. The bundle of primo-capillaries of the primo vessel is laid into an external jacket composed of endothelial cells with 6–12 μm spindle-like or oval nuclei.

The primo nodes are oval-shape of 0.1–0.5 mm along the short and 0.5–1 mm along the long axis, on both ends connected to primo vessels of 3–6 cm in length and 40–100 μm in diameter. The primo node is essentially the interlacement of broadened and branched primo-capillaries covered with a 5–40 μm thick capsule. A single capillary bundle (B) of the incoming (afferent) vessel enters the node, branches into additional bundles, and fills the node interior by tightly spun and folded bundles. Capillaries converge, narrow, and come out from the node as a single bundle of the efferent primo vessel.

The structural features of primo nodes, vessels, and capillaries observed with a high resolution light microscope are very different from those observed in blood and lymphatic vascular samples. Specifically, the jacketed architecture of primo vessels has no known parallel in other vascular systems.

The article was published in: "The Primo Vascular System", Springer. 83-94.

Full article

This work was supported (in part) by the Fetzer Franklin Fund of the John E. Fetzer Memorial Trust.

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PUBLICATIONS

CLASSICAL CAUSAL MODELS CANNOT FAITHFULLY EXPLAIN BELL NONLOCALITY OR KOCHEN-SPECKER CONTEXTUALITY IN ARBITRARY SCENARIOS

arXiv

In a recent work, it was shown by one of us (EGC) that Bell-Kochen-Specker inequality viola- tions in phenomena satisfying the no-disturbance condition (a generalisation of the no-signalling condition) cannot in general be explained with a faithful classical causal model—that is, a classical causal model that satisfies the assumption of no fine-tuning. The proof of that claim however was restricted to Bell scenarios involving 2 parties or Kochen-Specker-contextuality scenarios involving 2 measurements per context.

Here we show that the result holds in the general case of arbitrary numbers of parties or measurements per context; the connection between fine-tuning and Bell-KS inequality violations is generic and not an artefact of the simplest scenarios. This result unifies, in full generality, Bell nonlocality and Kochen-Specker contextuality as violations of a fundamental principle of classical causality.

The article was published in: arXiv preprint arXiv:1909.05434.

Full article

This work was supported (in part) by the Fetzer Franklin Fund of the John E. Fetzer Memorial Trust.

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YEAR
2019

FIELD OF SCIENCE
Physics

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PUBLICATIONS

COLLAPSE MODELS: FROM THEORETICAL FOUNDATIONS TO EXPERIMENTAL VERIFICATIONS

IOP Publishing

Info

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FIELD OF SCIENCE
Physics

The basic strategy underlying models of spontaneous wave function collapse (collapse models) is to modify the Schrödinger equation by including nonlinear stochastic terms, which tend to localize wave functions in space in a dynamical manner. These terms have negligible effects on microscopic systems—therefore their quantum behaviour is practically preserved.

On the other end, since the strength of these new terms scales with the mass of the system, they become dominant at the macroscopic level, making sure that wave functions of macro-objects are always well-localized in space. We will review these basic features. By changing the dynamics of quantum systems, collapse models make predictions, which are different from standard quantum mechanical predictions. Although they are difficult to detect, we discuss the most relevant scenarios, where such deviations can be observed.

The article was published in: Proceedings of: 'Journal of Physics: Conference Series', IOP Publishing: 012023.

Full article

This work was supported (in part) by the Fetzer Franklin Fund of the John E. Fetzer Memorial Trust.

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PUBLICATIONS

COLLAPSE MODELS: MAIN PROPERTIES AND THE STATE OF ART OF THE EXPERIMENTAL TESTS

arXiv

Collapse models represent one of the possible solutions to the measurement problem. These models modify the Schrödinger dynamics with non-linear and stochastic terms, which guarantee the localization in space of the wave function avoiding macroscopic superpositions, like that described in the Schrödinger's cat paradox.

The Ghirardi-Rimini-Weber (GRW) and the Continuous Spontaneous Localization (CSL) models are the most studied among the collapse models. Here, we briefly summarize the main features of these models and the advances in their experimental investigation.

The article was published in: *arXiv preprint arXiv:1907.12460*.

Full article

This work was supported (in part) by the Fetzer Franklin Fund of the John E. Fetzer Memorial Trust.

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YEAR
2019

FIELD OF SCIENCE
Physics

Back to Publications

PUBLICATIONS

COMPLETELY TOP–DOWN HIERARCHICAL STRUCTURE IN QUANTUM MECHANICS

Proceedings of the National Academy Science of the U.S.A. 115(46)

Can a large system be fully characterized using its subsystems via inductive reasoning? Is it possible to completely reduce the behavior of a complex system to the behavior of its simplest "atoms"? In this paper we answer these questions in the negative for a specific class of systems and measurements. After a general introduction of the topic, we present the main idea with a simple two-particle example, where strong correlations arise between two apparently empty boxes. This leads to surprising effects within atomic and electromagnetic systems.

A general construction based on pre- and postselected ensembles is then suggested, wherein the N-body correlation can be genuinely perceived as a global property, as long as one is limited to performing measurements which we term "strictly local." We conclude that under certain boundary conditions, higher-order correlations within quantum mechanical systems can determine lower-order ones, but not vice versa. Surprisingly, the lower-order correlations provide no information whatsoever regarding the higher-order correlations. This supports a top-down structure in many-body quantum mechanics.

The article was published in: Proceedings of the National Academy Science of the U.S.A. 115(46): 11730-11735.

Full article

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FIELD OF SCIENCE
Physics

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PUBLICATIONS

COMPLEXITY OF THE TASKLESS MIND AT DIFFERENT TIME-SCALES: AN EMPIRICALLY WEIGHTED APPROACH TO DECOMPOSITION AND MEASUREMENT

AIP Conference Proceedings 1339

The neurodynamical state of an eyes-closed at 'rest' subject is an area of keen interest in the neuroscience community due to Raichle's field changing concept of the Default Mode Network [1]. The dynamic analysis of neurobiologically derived data commonly involves the computation of distributional measures and time-frequency transforms, and more recently the use of ergodic measures. However, many of the methods used in these computations rely upon questionable assumptions such as stationarity or approximate linearity.

The Empirical Mode Decomposition of Huang et al.., [2], which preserves nonlinearity and non-stationarity, has led to alternative signal processing techniques. We append to this growing set of techniques a well-defined class of Weighting Functionals, WF. The strength is that they are easily applied to any number of time-frequency transforms and ergodic/complexity measurements because the WFs rescale all the results according to the proportion of energy contained at the individual time-scales.

The application to ergodic/complexity measurements has not been addressed in the context of Intrinsic Mode Functions, and is done so here for the first time. Our interest is to take these methods and demonstrate time dependence of the signal across multiple time-scales in the comparison of normal controls and a variety of psychopathological and neuropathological conditions.

The article was first published at: AIP Conference Proceedings 1339: 275-281.

Full article

This work was supported (in part) by the Fetzer Franklin Fund of the John E. Fetzer Memorial Trust.

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FIELD OF SCIENCE
Biology, Physics

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PUBLICATIONS

CONDITIONS FOR LORENTZ-INVARIANT SUPERLUMINAL INFORMATION TRANSFER WITHOUT SIGNALING

Journals of Physics. Conference Series, Volume 701(1)

Info

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YEAR
2016

FIELD OF SCIENCE
Physics

We understand emergent quantum mechanics in the sense that quantum mechanics describes processes of physical emergence relating an assumed sub-quantum physics to macroscopic boundary conditions. The latter can be shown to entail top-down causation, in addition to usual bottom-up scenarios. With this example it is demonstrated that definitions of "realism" in the literature are simply too restrictive.

A prevailing manner to define realism in quantum mechanics is in terms of pre-determination independent of the measurement. With our counter-example, which actually is ubiquitous in emergent, or self-organizing, systems, we argue for realism without pre-determination. We refer to earlier results of our group showing how the guiding equation of the de Broglie- Bohm interpretation can be derived from a theory with classical ingredients only. Essentially, this corresponds to a "quantum mechanics without wave functions" in ordinary 3-space, albeit with nonlocal correlations.

The article was published in: Journals of Physics. Conference Series, Volume 701(1): 012006.

Full article

This work was supported (in part) by the Fetzer Franklin Fund of the John E. Fetzer Memorial Trust.

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PUBLICATIONS

CONFINED CONTEXTUALITY IN NEUTRON INTERFEROMETRY: OBSERVING THE QUANTUM PIGEONHOLE EFFECT

Physical Revue A 96(5)

Previous experimental tests of quantum contextuality based on the Bell-Kochen-Specker (BKS) theorem have demonstrated that not all observables among a given set can be assigned noncontextual eigenvalue predictions, but have never identified which specific observables must fail such assignment. We now remedy this short- coming by showing that BKS contextuality can be confined to particular observables by pre- and postselection, resulting in anomalous weak values that we measure using modern neutron interferometry.

We construct a confined contextuality witness from weak values, which we measure experimentally to obtain a 5σ average violation of the noncontextual bound, with one contributing term violating an independent bound by more than 99σ. This weakly measured confined BKS contextuality also confirms the quantum pigeonhole effect, wherein eigenvalue assignments to contextual observables apparently violate the classical pigeonhole principle.

The article was published in: Physical Revue A 96(5): 052131.

Full article

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YEAR
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FIELD OF SCIENCE
Physics

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PUBLICATIONS

CONSCIOUSNESS AND THE DOUBLE-SLIT INTERFERENCE PATTERN: SIX EXPERIMENTS

Physics Essays 25(2)

A double-slit optical system was used to test the possible role of consciousness in the collapse of the quantum wavefunction. The ratio of the interference pattern's double-slit spectral power to its single-slit spectral power was predicted to decrease when attention was focused toward the double slit as compared to away from it. Each test session consisted of 40 counterbalanced attention-toward and attention-away epochs, where each epoch lasted between 15 and 30 s.

Data contributed by 137 people in six experiments, involving a total of 250 test sessions, indicate that on average the spectral ratio decreased as predicted (z=-4:36, p=6·10-6). Another 250 control sessions conducted without observers present tested hardware, software, and analytical procedures for potential artifacts; none were identified (z=0:43, p=0:67).

Variables including temperature, vibration, and signal drift were also tested, and no spurious influences were identified. By contrast, factors associated with consciousness, such as meditation experience, electrocortical markers of focused attention, and psychological factors including openness and absorption, significantly correlated in predicted ways with perturbations in the double-slit interference pattern. The results appear to be consistent with a consciousness-related interpretation of the quantum measurement problem.

The article was published in: Physics Essays 25(2): 157-171.

Full article

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YEAR
2012

FIELD OF SCIENCE
Physics

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PUBLICATIONS

CONSCIOUSNESS IN THE LIGHT OF QUANTUM THEORY

Consciousness: Integrating Eastern and Western Perspectives

Info

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YEAR
2016

FIELD OF SCIENCE
Consciousness

This volume brings together eastern and western perspectives on consciousness with essays from philosophers and scientists which emphasise different aspects of the integration. The overarching aim of this book is to provide direction toward integrating Eastern philosophical and religious practice with philosophies and science of Western culture, an aim that could be pivotal in understanding consciousness and its place in nature.

A unifying approach is adopted to the study of consciousness, integrating the wisdom of the sages of the east, and the scientists of the west and the stupendous east-west integration that has been achieved is indeed a milestone. The book will appeal to the rapidly growing mass of scientists and students in this upcoming field, both in the east and west, as well as the general inquisitive reader.

Courses in consciousness studies are being promoted in leading Universities all over the world. It will also interest the followers and adherents of Eastern Philosophy of Saints and Radhasoami Faith numbering in a few millions around the globe.

The article was published in: Consciousness: Integrating Eastern and Western Perspectives, P. S. Satsangi, S. Hameroff, V. Sani, et al. (Eds.). New Delhi: New Age Books. 23-34.

Full article

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PUBLICATIONS

CONTEXTUALITY, PIGEONHOLES, CHESHIRE CATS, MEAN KINGS, AND WEAK VALUES

Quantum Studies: Mathematics and Foundations 5(2)

Info

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YEAR
2018

FIELD OF SCIENCE
Physics

The structural connections between the Kochen-Specker (KS) theorem, pre- and post-selection (PPS) paradoxes, and anomalous weak values are explored in detail. All PPS paradoxes, such as the 3-box paradox, the Quantum Cheshire Cat, and the Quantum Pigeonhole principle, construct a particular type of ontological model that assigns an eigenvalue to each observable (independent of context) of a system such that these assignments are consistent with the PPS. It is shown that such an ontological model must be explicitly contextual in the sense of the KS theorem, or otherwise im- plies either a restriction on free random choice or explicitly retrocausal behavior. We call such models PPS-contextual.

The structure of each paradox is always such that there are particular contexts of mutually commuting observables that violate the prod- uct rule or sum rule, when the ontological model is extended to include observables that are not measured during the experiment. These paradoxes are counterfactual, in the sense that they are not directly observed, and also because the product and sum rules are always obeyed by projective measurements in actual experiments. It is shown that by adopting an alternate ontological model, where all hidden variables are weak values (which are not always eigenvalues, but obey the sum rule by definition), the same contexts that presented the original paradox must also contain observables with anomalous weak values.

These anomalous weak values are not counterfactual because they can be probed through weak measurements on an ensemble of identically pre- and post-selected states, allowing this localized signature of KS contextuality to be experi- mentally observed. The weak values of all observables of a system can in principle be measured during an experiment, making this model a promising candidate for describ- ing PPS-contextual ontological 'elements of reality.' As a related issue, we show using the mathematical properties of weak values, that any KS set can be used to ensure that the Mean King always wins his game against the stranded physicist.

The article was published in: Quantum Studies: Mathematics and Foundations 5(2): 325-349.

Full article

This work was supported (in part) by the Fetzer Franklin Fund of the John E. Fetzer Memorial Trust.

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PUBLICATIONS

CONTRA CLASSICAL CAUSALITY VIOLATING TEMPORAL BELL INEQUALITIES IN MENTAL SYSTEMS

Journal of Consciousness Studies 19(5-6)

Temporally non-local measurements -- single measurements yielding information about the state of a system at different instances -- may provide a way to observe non-classical behaviour in mental systems. The signature for such behaviour is a violation of temporal Bell inequalities.

We present such inequalities applicable to scenarios with two alternating mental states, such as in the perception of ambiguous figures. We indicate empirical options for testing temporal Bell inequalities, and speculate about possible explanations in case these inequalities are indeed violated.

The article was published in: Journal of Consciousness Studies 19(5-6): 95-116.

Full article

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YEAR
2012

FIELD OF SCIENCE
Consciousness, Physics

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PUBLICATIONS

CONTROLLING ORGANIZATION AND FORCES IN ACTIVE MATTER THROUGH OPTICALLY DEFINED BOUNDARIES

Nature 572(7768)

Info

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YEAR
2018

FIELD OF SCIENCE
Physics

Living systems are capable of locomotion, reconfiguration, and replication. To perform these tasks, cells spatiotemporally coordinate the interactions of force-generating, “active” molecules that create and manipulate non-equilibrium structures and force fields that span up to millime- ter length scales [1–3]. Experimental active matter systems of biological or synthetic molecules are capable of spontaneously organizing into structures [4, 5] and generating global flows [6– 9]. However, these experimental systems lack the spatiotemporal control found in cells, lim- iting their utility for studying non-equilibrium phenomena and bioinspired engineering.

Here, we uncover non-equilibrium phenomena and principles by optically controlling structures and fluid flow in an engineered system of active biomolecules. Our engineered system consists of purified microtubules and light-activatable motor proteins that crosslink and organize micro- tubules into distinct structures upon illumination. We develop basic operations, defined as sets of light patterns, to create, move, and merge microtubule structures.

By composing these basic operations, we are able to create microtubule networks that span several hundred microns in length and contract at speeds up to an order of magnitude faster than the speed of an individ- ual motor. We manipulate these contractile networks to generate and sculpt persistent fluid flows. The principles of boundary-mediated control we uncover may be used to study emergent cellular structures and forces and to develop programmable active matter devices.

The article was published in: Nature 572(7768): 224-229.

Full article

This work was supported (in part) by the Fetzer Franklin Fund of the John E. Fetzer Memorial Trust.

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PUBLICATIONS

DAYDREAMING, THOUGHT BLOCKING AND STRUDELS IN THE TASKLESS, RESTING HUMAN BRAIN'S MAGNETIC FIELDS

AIP Conference Proceedings

The incidence, *i*(S), and duration, *I*(S), of transient, intermittent, hierarchical vorticities,*strudels*, S, in magnetic flux fluctuations, were computed from MEG records. from 91 task-free resting subjects. The MEG's *i*(S) and *I*(S) manifested characteristic times and entropic sensitivity resembling those reported in psychological studies of daydreaming and task-unrelated thoughts, TUTs.

Transient reduction or absences of strudels can be found in patients with syndromes characterized by *thought blocking*. Positive ergodic single orbit measures of expansiveness and mixing predict *i*(S) and *I*(S). An analogy with the relationship between intermittent *pontine-geniculate-occipital* waves and *dreaming* is made to *strudels*with *daydreaming*. Both can be interpreted as neurophysiological correlates of the spontaneous intrusions into consciousness of the never idle unconscious mind.

The article was published at: AIP Conference Proceedings 1339 (International Conference on Applications in Nonlinear Dynamics (ICAND 2010))(1): 7-22.

Full article

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FIELD OF SCIENCE
Physics

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PUBLICATIONS

DECLINE EFFECTS – TYPES, MECHANISMS, AND PERSONAL REFLECTIONS

Psychological science under scrutiny: Recent challenges and proposed solutions

Info

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YEAR
2017

FIELD OF SCIENCE
Consciousness

It is tempting to believe that scientific findings provide an accurate account of enduring reality. The indisputable success of the scientific enterprise is testament to the significant degree to which initially reported findings can be replicated and built upon. Nevertheless, a substantial number of findings are less robust and less substantial than they initially appear.

Some effects that were present have declined over time. Appreciation of the unreliability of scientific findings has led to what some have termed the replication crisis, as a variety of areas including biology (Begley & Ellis, 2012), psychology (Bakker, van Dijk, & Wicherts, 2012), and genetics (Siontis, Patsopoulos, & Ioannidis, 2010) have come to recognize - that a striking number of studies in their respective fields no longer replicate.

The article was published in: Psychological science under scrutiny: Recent challenges and proposed solutions, S. O. Lilienfeld and I. D. Waldman (Eds.). 85-106.

Full article

This work was supported (in part) by the Fetzer Franklin Fund of the John E. Fetzer Memorial Trust.

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PUBLICATIONS

DECOHERENCE IN CRYSTALS OF QUANTUM MOLECULAR MAGNETS

Nature 476

Quantum decoherence is a central concept in physics. Applications such as quantum information processing depend on understanding it; there are even fundamental theories proposed that go beyond quantum mechanics, in which the breakdown of quantum theory would appear as an 'intrinsic' decoherence, mimicking the more familiar environmental decoherence processes. Such applications cannot be optimized, and such theories cannot be tested, until we have a firm handle on ordinary environmental decoherence processes. Here we show that the theory for insulating electronic spin systems can make accurate and testable predictions for environmental decoherence in molecular-based quantum magnets.

Experiments on molecular magnets have successfully demonstrated quantum-coherent phenomena, but the decoherence processes that ultimately limit such behaviour were not well constrained. For molecular magnets, theory predicts three principal contributions to environmental decoherence: from phonons, from nuclear spins and from intermolecular dipolar interactions. We use high magnetic fields on single crystals of Fe8 molecular magnets (in which the Fe ions are surrounded by organic ligands) to suppress dipolar and nuclear-spin decoherence.

In these high-field experiments, we find that the decoherence time varies strongly as a function of temperature and magnetic field. The theoretical predictions are fully verified experimentally, and there are no other visible decoherence sources. In these high fields, we obtain a maximum decoherence quality-factor of 1.49 × 106; our investigation suggests that the environmental decoherence time can be extended up to about 500 microseconds, with a decoherence quality factor of ~6 × 107, by optimizing the temperature, magnetic field and nuclear isotopic.

The article was published in: Nature 476(7358): 76.

Full article

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YEAR
2011

FIELD OF SCIENCE
Physics

Back to Publications

PUBLICATIONS

DIRAC, BOHM AND THE ALGEBRAIC APPROACH

arXiv

In this paper we show how Dirac, in 1947, anticipated the Bohm ap- proach using an argument based on what is now called the Heisenberg picture. From a detailed examination of these ideas, we show that the role played by the Dirac standard ket is equivalent to the introduction and use of the idempotent in the orthogonal and symplectic Clifford algebras.

This formalism is then used to show that the so-called 'Bohm trajectories' are the average of an ensemble of individual stochastic Feynman paths. Since the Bohm approach can be simply reduced to classical mechanics, the algebraic formalism presented here provides a natural way to relate quantum mechanics to classical mechanics with- out the need for decoherence. We show that this approach suggests an underlying fractal space-time of the type discussed by Nottale.

The article was published in: arXiv preprint arXiv:1901.01979.

Full article

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YEAR
2019

FIELD OF SCIENCE
Physics

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PUBLICATIONS

DO CALCIFYING NANOPARTICLES PROMOTE NEPHROLITHIASIS?

Clinical Nephrology 71

Info

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YEAR
2009

FIELD OF SCIENCE
Biology

Although much has been learned regarding the pathogenesis of kidney stones, the reason(s) why some individuals form stones while others do not remains incompletely understood. Nanoparticles, which have been observed in geologic samples, have also been isolated from biologic specimens, including kidney stones. These nanoparticles have certain properties that are consistent with a novel life form, including in vitro self-replication, and contain lipids, DNA and proteins. Therefore, it has been hypothesized that nanoparticles may represent a type of infective agent that initiates stone formation in some individuals.

Despite a large body of intriguing and suggestive evidence, the true biologic nature of these entities has been elusive, and controversy remains as to whether these nano-sized particles are analogous to other recently described unusual and novel microorganisms, or a transmissible, yet inert nanoparticle. Although unique DNA or RNA has yet to be identified, a proteomic biosignature is beginning to emerge that may allow more definitive clinical investigation. This review evaluates the current evidence regarding nanoparticles as causal to disease and emphasizes the need for additional research to further elucidate their role in human stone formation.

The article was published in: Clinical Nephrology (71: 1-8.)

Full article

This work was supported (in part) by the Fetzer Franklin Fund of the John E. Fetzer Memorial Trust.

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PUBLICATIONS

ELEMENTS OF PHYSICS FOR THE 21ST CENTURY

Journal of Physics Conference Series

Info

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YEAR
2014

FIELD OF SCIENCE
Physics

Given the experimental precision in condensed matter physics -- positions are measured with errors of less than 0.1pm, energies with about 0.1meV, and temperature levels are below 20mK -- it can be inferred that standard quantum mechanics, with its inherent uncertainties, is a model at the end of its natural lifetime. In this presentation I explore the elements of a future deterministic framework based on the synthesis of wave mechanics and density functional theory at the single-electron level.

The article was published in: Proceedings of: 'Journal of Physics: Conference Series', IOP Publishing: 012014.

Full article

This work was supported (in part) by the Fetzer Franklin Fund of the John E. Fetzer Memorial Trust.

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PUBLICATIONS

EMERGENCE OF QUANTUM MECHANICS FROM A SUB-QUANTUM STATISTICAL MECHANICS

arXiv

Info

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YEAR
2014

FIELD OF SCIENCE
Physics

A research program within the scope of theories on "Emergent Quantum Mechanics" is presented, which has gained some momentum in recent years. Via the modeling of a quantum system as a non-equilibrium steady-state maintained by a permanent throughput of energy from the zero-point vacuum, the quantum is considered as an emergent system.

We implement a specific "bouncer- walker" model in the context of an assumed sub-quantum statistical physics, in analogy to the results of experiments by Couder's group on a classical wave-particle duality. We can thus give an explanation of various quantum mechanical features and results on the basis of a "21st century classical physics", such as the appearance of Planck's constant, the Schrödinger equation, etc. An essential result is given by the proof that averaged particle trajectories' behaviors correspond to a specific type of anomalous diffusion termed "ballistic" diffusion on a sub-quantum level.

It is further demonstrated both analytically and with the aid of computer simulations that our model provides explanations for various quantum effects such as double-slit or n-slit interference. We show the averaged trajectories emerging from our model to be identical to Bohmian trajectories, albeit without the need to invoke complex wave functions or any other quantum mechanical tool. Finally, the model provides new insights into the origins of entanglement, and, in particular, into the phenomenon of a "systemic" nonlocality.

The article was published in: International Journal of Modern Physics B 28.

Full article

This work was supported (in part) by the Fetzer Franklin Fund of the John E. Fetzer Memorial Trust.

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PUBLICATIONS

EMERGENT QUANTUM MECHANICS – DAVID BOHM CENTENNIAL PERSPECTIVES

Entropy

Info

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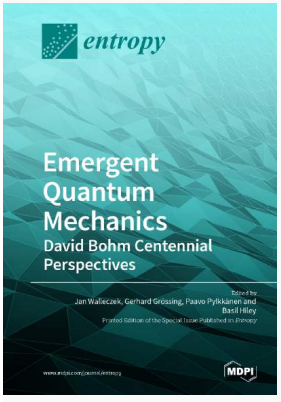
YEAR
2019

FIELD OF SCIENCE
Physics



This publication is a result of the EmQM17 conference.

On the occasion of David Bohm's 100th birthday, a symposium on emergent quantum mechanics was held at the University of London, Senate House, on October 26-28, 2017.

The Special Issue features expert views that critically evaluate the prospects and significance—for 21st century physics—of ontological quantum mechanics, an approach which David Bohm helped pioneer.

Emergent quantum mechanics (EmQM) explores the possibility of an ontology for quantum mechanics. The resurgence of interest in realist approaches to quantum mechanics challenges the standard textbook view, which represents an operationalist approach. The possibility of an ontological, i.e., realist, quantum mechanics was first introduced with the original de Broglie-Bohm theory, which has also been developed in another context as Bohmian mechanics. This book features expert contributions which were invited as part of the David Bohm Centennial symposium of the EmQM conference series.

Questions directing the EmQM research agenda are: Is reality intrinsically random or fundamentally interconnected? Is the universe local or nonlocal? Might a radically new conception of reality include a form of quantum causality or quantum ontology? What is the role of the experimenter agent in ontological quantum mechanics? The book features research examining ontological propositions also that are not based on the Bohm-type nonlocality. These include, for example, local, yet time-symmetric, ontologies, such as quantum models based upon retrocausality. The book offers thirty-two contributions which are organized into seven categories to provide orientation as is outlined in the Editorial contribution in the beginning of the book.

Topics of the Special Issue:

- Interpretations of Quantum Mechanics
- Nonlocality and Violation of Bell Inequalities
- Quantum Probabilities and Contextuality
- Quantum Causality and Ontology
- Information Measures in Quantum Theory
- Quantum Observation and the Physics of the Experimenter Agent
- Nonlinear Methods applied to Quantum Theory
- Self-organization and Quantum Emergence
- Hidden Variable Theories and Relativity
- Emergent Space-time

Full book as a free pdf

The book is also available as a printed copy published at MDPI books:

Order here

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PUBLICATIONS

EMERGENT QUANTUM MECHANICS WITHOUT WAVEFUNCTIONS

'Journal of Physics: Conference Series'

We present our model of an Emergent Quantum Mechanics which can be characterized by "realism without pre-determination". This is illustrated by our analytic description and corresponding computer simulations of Bohmian-like "surreal" trajectories, which are obtained classically, i.e. without the use of any quantum mechanical tool such as wavefunctions.

However, these trajectories do not necessarily represent ontological paths of particles but rather mappings of the probability density flux in a hydrodynamical sense. Modelling emergent quantum mechanics in a high-low intesity double slit scenario gives rise to the "quantum sweeper effect" with a characteristic intensity pattern. This phenomenon should be experimentally testable via weak measurement techniques.

The article was published in: Proceedings of: 'Journal of Physics: Conference Series', IOP Publishing: 012036.

Full article

This work was supported (in part) by the Fetzer Franklin Fund of the John E. Fetzer Memorial Trust.

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YEAR
2016

FIELD OF SCIENCE
Physics

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PUBLICATIONS

ENTERTAINING WITHOUT ENDORSING: THE CASE FOR THE SCIENTIFIC INVESTIGATION OF ANOMALOUS COGNITION

Psychology of Consciousness: Theory, Research, and Practice

Info

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YEAR
2018

FIELD OF SCIENCE
Consciousness

Empirical reports in mainstream journals that human cognition extends in ways that challenge the current boundaries of science (anomalous cognition) has been viewed with dismay by many who see it as evidence that science is broken. Here the authors make the case for the value of conducting and publishing well-designed studies investigating anomalous cognition.

They distinguish between the criteria that justify entertaining the possibility of anomalous cognition from those required to endorse it as a bona fide phenomenon. In evaluating these 2 distinct thresholds, the authors draw on Bayes's theorem to argue that scientists may reasonably differ in their appraisals of the likelihood that anomalous cognition is possible.

Although individual scientists may usefully vary in the criteria that they hold both for entertaining and endorsing anomalous cognition, we provide arguments for why researchers should consider adopting a liberal criterion for entertaining anomalous cognition while maintaining a very strict criterion for the outright endorsement of its existence.

Grounded in an understanding of the justifiability of disparate views on the topic, the authors encourage humility on both the part of those who present evidence in support of anomalous cognition and those who dispute the merit of its investigation.

The article was published in: Psychology of Consciousness: Theory, Research, and Practice 5(1): 63.

Full article

This work was supported (in part) by the Fetzer Franklin Fund of the John E. Fetzer Memorial Trust.

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PUBLICATIONS

EPISTEMIC ENTANGLEMENT DUE TO NON-GENERATING PARTITIONS OF CLASSICAL DYNAMICAL SYSTEMS

International journal of theoretical physics 52(3)

Quantum entanglement relies on the fact that pure quantum states are dispersive and often inseparable. Since pure classical states are dispersion-free they are always separable and cannot be entangled. However, entanglement is possible for epistemic, dispersive classical states. We show how such epistemic entanglement arises for epistemic states of classical dynamical systems based on phase space partitions that are not generating. We compute epistemically entangled states for two coupled harmonic oscillators.

The article was published in: International journal of theoretical physics 52(3): 723-734.

Full article

This work was supported (in part) by the Fetzer Franklin Fund of the John E. Fetzer Memorial Trust.

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YEAR
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FIELD OF SCIENCE
Physics

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PUBLICATIONS

EXPERIMENTAL CHARACTERIZATION AND MODELING OF CONTRACTILE BEHAVIOR AND FLUID FLOWS IN AN OPTICALLY-CONTROLLED MICROTUBULE NETWORK

Bulletin of the American Physical Society

Info

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YEAR
2019

FIELD OF SCIENCE
Physics

Cells perform physical tasks (genome seg- regation, movement) by organizing the activity of force-generating, active molecules in time and space. Most experimental active matter systems of biological or syn- thetic molecules are capable of spontaneously organizing into structures and gener- ating global flows while lacking the spatiotemporal control found in cells, limiting their utility for studying non-equilibrium phenomena and bioinspired engineering.

Here, we use an optically-controlled active matter system, consisting of stabilized mi- crotubule filaments and kinesin motors, to demonstrate a series of simple operations by projecting various light patterns including both concave and convex polygons. The light patterns activate a reversible link between the kinesin motors which pull on microtubules.

A two-phase contracting behavior is observed. The first phase includes a fast formation of microtubule network and its uniform contraction. The second phase is dominated by the steady state flow established afterwards. Two separate mathematical models are proposed to study these behaviors.

The article was published in: Bulletin of the American Physical Society.

Full article

This work was supported (in part) by the Fetzer Franklin Fund of the John E. Fetzer Memorial Trust.

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PUBLICATIONS

EXPERIMENTAL DEMONSTRATION OF DIRECT PATH STATE CHARACTERIZATION BY STRONGLY MEASURING WEAK VALUES IN A MATTER-WAVE INTERFEROMETER

Physical review letters 118(1)

A novel method was recently proposed and experimentally realized for characterizing a quantum state by directly measuring its complex probability amplitudes in a particular basis using so-called weak values. Recently Vallone and Dequal showed theoretically that weak measurements are not a necessary condition to determine the weak value [Phys. Rev. Lett. 116, 040502 (2016)].

Here we report a measurement scheme used in a matter-wave interferometric experiment in which the neutron path system's quantum state was characterized via direct measurements using both strong and weak interactions. Experimental evidence is given that strong interactions outperform weak ones. Our results are not limited to neutron interferometry, but can be used in a wide range of quantum systems.

The article was published in: Physical review letters 118(1): 010402.

Full article

This work was supported (in part) by the Fetzer Franklin Fund of the John E. Fetzer Memorial Trust.

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YEAR
2017

FIELD OF SCIENCE
Physics

Back to Publications

PUBLICATIONS

EXTRACTING AND MATCHING AUTHORS AND AFFILIATIONS IN SCHOLARLY DOCUMENTS

Proceedings of the 13th ACM/IEEE-CS joint conference on Digital libraries

We introduce Enlil, an information extraction system that discovers the institutional affiliations of authors in scholarly papers. Enlil consists of two steps: one that first identifies authors and affiliations using a conditional random field; and a second support vector machine that connects authors to their affiliations. We benchmark Enlil in three separate experiments drawn from three different sources: the ACL Anthology, the ACM Digital Library, and a set of cross-disciplinary scientific journal articles acquired by querying Google Scholar.

Against a state-of-the-art production baseline, Enlil reports a statistically significant improvement in F1 of nearly 10% ($p \ll 0.01$). In the case of multidisciplinary articles from Google Scholar, Enlil is benchmarked over both clean input (F1 > 90%) and automatically-acquired input (F1 > 80%). We have deployed Enlil in a case study involving Asian genomics research publication patterns to understand how government sponsored collaborative links evolve. Enlil has enabled our team to construct and validate new metrics to quantify the facilitation of research as opposed to direct publication.

The article was published in: Proceedings of: 'Proceedings of the 13th ACM/IEEE-CS joint conference on Digital libraries', Indianapolis, Indiana, USA, ACM: 219-228.

Full article

This work was supported (in part) by the Fetzer Franklin Fund of the John E. Fetzer Memorial Trust.

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FIELD OF SCIENCE
Foundations

Back to Publications

PUBLICATIONS

EXTREME BEAM ATTENUATION IN DOUBLE-SLIT EXPERIMENTS: QUANTUM AND SUBQUANTUM SCENARIOS

Annals of Physics 353

Combining high and low probability densities in intensity hybrids, we study some of their proper- ties in double-slit setups. In particular, we connect to earlier results on beam attenuation techniques in neutron interferometry and study the effects of very small transmission factors, or very low count- ing rates, respectively, at one of the two slits. We use a “superclassical” modeling procedure which we have previously shown to produce predictions identical with those of standard quantum theory.

Although in accordance with the latter, we show that there are previously unexpected new effects in intensity hybrids for transmission factors below a < 10−4, which can eventually be observed with the aid of weak measurement techniques. We denote these as quantum sweeper effects, which are characterized by the bunching together of low counting rate particles within very narrow spatial domains.

We give an explanation of this phenomenology by the circumstance that in reaching down to ever weaker channel intensities, the nonlinear nature of the probability density currents becomes ever more important, a fact which is generally not considered – although implicitly present – in standard quantum mechanics.

The article was published in: Annals of Physics 353: 271-281.

Full article

This work was supported (in part) by the Fetzer Franklin Fund of the John E. Fetzer Memorial Trust.

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YEAR
2015

FIELD OF SCIENCE
Physics

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PUBLICATIONS

FALSE-POSITIVE EFFECT IN THE RADIN DOUBLE-SLIT EXPERIMENT ON OBSERVER CONSCIOUSNESS AS DETERMINED WITH THE ADVANCED META-EXPERIMENTAL PROTOCOL (AMP)

Frontiers in Psychology

Prior work by Radin et al. (2012, 2016) reported the astonishing claim that an anomalous effect on double-slit (DS) light-interference intensity had been measured as a function of quantum-based observer consciousness. Given the radical implications, could there exist an alternative explanation, other than an anomalous consciousness effect, such as artifacts including systematic methodological error (SME)?

To address this question, a conceptual replication study involving 10,000 test trials was commissioned to be performed blindly by the same investigator who had reported the original results.

The commissioned study performed confirmatory and strictly predictive tests with the advanced meta-experimental protocol (AMP), including with systematic negative controls and the concept of the sham-experiment, i.e., counterfactual meta-experimentation. Whereas the replication study was unable to confirm the original results, the AMP was able to identify an unacceptably low true-negative detection rate with the sham-experiment in the absence of test subjects.

The false-positive detection rate reached 50%, whereby the false-positive effect, which would be indistinguishable from the predicted true-positive effect, was significant at $p = 0.021$ ($\sigma = -2.02$; $N = 1{,}250$ test trials). The false-positive effect size was about 0.01%, which is within an-order-of-magnitude of the claimed consciousness effect (0.001%; Radin et al., 2016). The false-positive effect, which indicates the presence of significant SME in the Radin DS-experiment, suggests that skepticism should replace optimism concerning the radical claim that an anomalous quantum consciousness effect has been observed in a controlled laboratory setting.

Full article

This work was (in part) supported by the Fetzer Franklin Fund.

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YEAR
2019

FIELD OF SCIENCE
Foundations, Physics

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PUBLICATIONS

FALSE-POSITIVE EFFECT IN THE RADIN DOUBLE-SLIT EXPERIMENT ON OBSERVER CONSCIOUSNESS AS DETERMINED WITH THE ADVANCED META-EXPERIMENTAL PROTOCOL

Frontiers in Psychology 10

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FIELD OF SCIENCE
Consciousness, Physics

Prior work by Radin et al. (2012, 2016) reported the astonishing claim that an anomalous effect on double-slit (DS) light-interference intensity had been measured as a function of quantum-based observer consciousness. Given the radical implications, could there exist an alternative explanation, other than an anomalous consciousness effect, such as artifacts including systematic methodological error (SME)?

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The article was published in: Frontiers in Psychology 10

Full article

This work was supported (in part) by the Fetzer Franklin Fund of the John E. Fetzer Memorial Trust.

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YEAR
2018

FIELD OF SCIENCE
Physics

Back to Publications

PUBLICATIONS

FEYNMAN PATHS AND WEAK VALUES

Entropy 20(5)

There has been a recent revival of interest in the notion of a 'trajectory' of a quantum particle. In this paper, we detail the relationship between Dirac's ideas, Feynman paths and the Bohm approach. The key to the relationship is the weak value of the momentum which Feynman calls a transition probability amplitude.

With this identification we are able to conclude that a Bohm 'trajectory' is the average of an ensemble of actual individual stochastic Feynman paths. This implies that they can be interpreted as the mean momentum flow of a set of individual quantum processes and not the path of an individual particle. This enables us to give a clearer account of the experimental two-slit results of Kocsis et al.

The article was published in: Entropy 20(5): 367.

This work was supported (in part) by the Fetzer Franklin Fund of the John E. Fetzer Memorial Trust.

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PUBLICATIONS

FINALLY MAKING SENSE OF THE DOUBLE-SLIT EXPERIMENT

Proceedings of the National Academy of Sciences 114(25)

Feynman stated that the double-slit experiment "...has in it the heart of quantum mechanics. In reality, it contains the only mystery" and that "nobody can give you a deeper explanation of this phenomenon than I have given; that is, a description of it" [Feynman R, Leighton R, Sands M (1965) The Feynman Lectures on Physics]. We rise to the challenge with an alternative to the wave function-centered interpretations: instead of a quantum wave passing through both slits, we have a localized particle with nonlocal interactions with the other slit.

Key to this explanation is dynamical nonlocality, which naturally appears in the Heisenberg picture as nonlocal equations of motion. This insight led us to develop an approach to quantum mechanics which relies on pre- and postselection, weak measurements, deterministic, and modular variables. We consider those properties of a single particle that are deterministic to be primal. The Heisenberg picture allows us to specify the most complete enumeration of such deterministic properties in contrast to the Schrödinger wave function, which remains an ensemble property.

We exercise this approach by analyzing a version of the double-slit experiment augmented with postselection, showing that only it and not the wave function approach can be accommodated within a time-symmetric interpretation, where interference appears even when the particle is localized. Although the Heisenberg and Schrödinger pictures are equivalent formulations, nevertheless, the framework presented here has led to insights, intuitions, and experiments that were missed from the old perspective.

The article was published in: Proceedings of the National Academy of Sciences 114(25): 6480-6485.

Full article

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YEAR
2017

FIELD OF SCIENCE
Physics

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PUBLICATIONS

FOUNDATIONS OF RELATIONAL REALISM: A TOPOLOGICAL APPROACH TO QUANTUM MECHANICS AND THE PHILOSOPHY OF NATURE

Lexington Books

Info

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YEAR
2013

FIELD OF SCIENCE
Physics

If there is a central conceptual framework that has reliably borne the weight of modern physics as it ascends into the twenty-first century, it is the framework of quantum mechanics. Because of its enduring stability in experimental application, physics has today reached heights that not only inspire wonder, but arguably exceed the limits of intuitive vision, if not intuitive comprehension. For many physicists and philosophers, however, the currently fashionable tendency toward exotic interpretation of the theoretical formalism is recognized not as a mark of ascent for the tower of physics, but rather an indicator of sway—one that must be dampened rather than encouraged if practical progress is to continue.

In this unique two-part volume, designed to be comprehensible to both specialists and non-specialists, the authors chart out a pathway forward by identifying the central deficiency in most interpretations of quantum mechanics: That in its conventional, metrical depiction of extension, inherited from the Enlightenment, objects are characterized as fundamental to relations—i.e., such that relations presuppose objects but objects do not presuppose relations. The authors, by contrast, argue that quantum mechanics exemplifies the fact that physical extensiveness is fundamentally topological rather than metrical, with its proper logico-mathematical framework being category theoretic rather than set theoretic.

By this thesis, extensiveness fundamentally entails not only relations of objects, but also relations of relations. Thus, the fundamental quanta of quantum physics are properly defined as units of logico-physical relation rather than merely units of physical relata as is the current convention. Objects are always understood as relata, and likewise relations are always understood objectively. In this way, objects and relations are coherently defined as mutually implicative. The conventional notion of a history as "a story about fundamental objects" is thereby reversed, such that the classical "objects" become the story by which we understand physical systems that are fundamentally histories of quantum events.

These are just a few of the novel critical claims explored in this volume—claims whose exemplification in quantum mechanics will, the authors argue, serve more broadly as foundational principles for the philosophy of nature as it evolves through the twenty-first century and beyond.

The publication was published in: Lexington Books, 20.06.2013.

Full e-book

This work was supported (in part) by the Fetzer Franklin Fund of the John E. Fetzer Memorial Trust.

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PUBLICATIONS

FROM RESEARCH TO CLINIC: A SENSOR REDUCTION METHOD FOR HIGH-DENSITY EEG NEUROFEEDBACK SYSTEMS

Clinical Neurophysiology

Info

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FIELD OF SCIENCE
Biology, Consciousness

Objective

To accurately deliver a source-estimated neurofeedback (NF) signal developed on a 128-sensors EEG system on a reduced 32-sensors EEG system.

Methods

A linearly constrained minimum variance beamformer algorithm was used to select the 64 sensors which contributed most highly to the source signal. Monte Carlo-based sampling was then used to randomly generate a large set of reduced 32-sensors montages from the 64 beamformer-selected sensors. The reduced montages were then tested for their ability to reproduce the 128-sensors NF. The high-performing montages were then pooled and analyzed by a k-means clustering machine learning algorithm to produce an optimized reduced 32-sensors montage.

Results

Nearly 4500 high-performing montages were discovered from the Monte Carlo sampling. After statistically analyzing this pool of high performing montages, a set of refined 32-sensors montages was generated that could reproduce the 128-sensors NF with greater than 80% accuracy for 72% of the test population.

Conclusion

Our Monte Carlo reduction method was used to create reliable reduced-sensors montages which could be used to deliver accurate NF in clinical settings.

Significance

A translational pathway is now available by which high-density EEG-based NF measures can be delivered using clinically accessible low-density EEG systems.

The article was published in: Clinical Neurophysiology 130(3): 352-358.

Full article

This work was supported (in part) by the Fetzer Franklin Fund of the John E. Fetzer Memorial Trust.

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PUBLICATIONS

FUNDAMENTAL IRREVERSIBILITY: PLANCKIAN OR SCHRÖDINGER–NEWTON?

Entropy 20(7)

The inception of a universal gravity-related irreversibility took place originally in quantum cos- mology. The ultimate reason of universal irreversibility is thought to come from black holes close to the Planck scale. Completely different instances of irreversibilities are quantum state reductions unrelated to gravity or relativity but related to measurement devices.

However, an intricate relation- ship between Newton gravity and quantized matter might result in fundamental and spontaneous quantum state reduction — in the non-relativistic Schrödinger-Newton context. The above two concepts of fundamental irreversibility emerged and evolved with few or even no interactions. The purpose here is to draw a parallel between the two approaches first, and to ask rather than answer the question: can both the Planckian and the Schrödinger-Newton indeterminacies/irreversibilities be two faces of the same universe. A related personal note of the author's 1986 meeting with Aharonov and Bohm is appended.

The article was published in: Entropy 20(7): 496.

Full article

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2018

FIELD OF SCIENCE
Physics

Back to Publications

PUBLICATIONS

FUNDAMENTAL IS NON-RANDOM

What is Fundamental? Springer.

Info

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YEAR
2019

FIELD OF SCIENCE
Physics

Although we use randomness when we don't know any better, a principle of indifference cannot be used to explain anything interesting or fundamental. For example, in thermodynamics it can be shown that the real explanatory work is being done by the Second Law, not the equal a priori probability postulate. But to explain the interesting Second Law, many physicists try to retreat to a "random explanation," which fails. Looking at this problem from a different perspective reveals a natural solution: boundary-based explanations that arguably should be viewed as no less fundamental than other physical laws.
The article was published in: What is Fundamental? Springer. 135-146.

This work was supported (in part) by the Fetzer Franklin Fund of the John E. Fetzer Memorial Trust.

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PUBLICATIONS

GENERALISED QUANTUM THEORY—BASIC IDEA AND GENERAL INTUITION: A BACKGROUND STORY AND OVERVIEW

Axiomathes 21(2): 185-209.

Science is always presupposing some basic concepts that are held to be useful. These absolute presuppositions (Collingwood) are rarely debated and form the framework for what has been termed "paradigm" by Kuhn. Our currently accepted scientific model is predicated on a set of presuppositions that have difficulty accommodating holistic structures and relationships and are not geared towards incorporating non-local correlations. Since the theoretical models we hold also determine what we perceive and take as scientifically viable, it is important to look for an alternative model that can deal with holistic relationships.

One approach is to generalise algebraic quantum theory, which is an inherently holistic framework, into a generic model. Relaxing some restrictions and definitions from quantum theory proper yields an axiomatic framework that can be applied to any type of system. Most importantly, it keeps the core of the quantum theoretical formalism. It is capable of handling complementary observables, i.e. descriptors which are non-commuting, incompatible and yet collectively required to fully describe certain situations. It also predicts a generalised form of non-local correlations that in quantum theory are known as entanglement.

This generalised version is not quantum entanglement but an analogue form of holistic, non-local connectedness of elements within systems, predicted to occur whenever elements within systems are described by observables which are complementary to the description of the whole system. While a considerable body of circumstantial evidence supports the plausibility of the model, we are not yet in a position to use it for clear cut predictions that could be experimentally falsified. The series of papers offered in this special issue are the beginning of what we hope will become a rich scientific debate.

The article was published in: Axiomathes 21(2): 185-209.

Full article

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FIELD OF SCIENCE
Physics

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PUBLICATIONS

GENERALIZED QUANTUM THEORY: OVERVIEW AND LATEST DEVELOPMENTS

Axiomathes 21(2)

The main formal structures of Generalized Quantum Theory are summarized. Recent progress has sharpened some of the concepts, in particular the notion of an observable, the action of an observable on states (putting more emphasis on the role of proposition observables), and the concept of generalized entanglement. Furthermore, the active role of the observer in the structure of observables and the partitioning of systems is emphasized.

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Full article

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FIELD OF SCIENCE
Physics

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PUBLICATIONS

GRAVITATIONAL SENSING WITH WEAK VALUE BASED OPTICAL SENSORS

Quantum Studies: Mathematics and Foundations 6(2)

Using weak values amplification angular resolution limits, we theoretically investigate the gravita- tional sensing of objects. By inserting a force-sensing pendulum into a weak values interferometer, the optical response can sense accelerations to a few 10's of zepto-g Hz -1/2, with optical powers of 1mW. We convert this precision into range and mass sensitivity, focusing in detail on simple and torsion pendula. Various noise sources present are discussed, as well as the necessary cooling that should be applied to reach the desired levels of precision.

The article was published in: *Quantum Studies: Mathematics and Foundations* 6(2): 169-180.

Full article

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FIELD OF SCIENCE
Physics

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PUBLICATIONS

GROUPS AND EMOTIONAL AROUSAL MEDIATE NEURAL SYNCHRONY AND PERCEIVED RITUAL EFFICACY

frontiers in Psychology

We present the first neurophysiological signatures showing distinctive effects of group social context and emotional arousal on cultural perceptions, such as the efficacy of religious rituals. Using a novel protocol, EEG data were simultaneously recorded from ethnic Chinese religious believers in group and individual settings as they rated the perceived efficacy of low, medium, and high arousal spirit-medium rituals presented as video clips. Neural oscillatory patterns were then analyzed for these perceptual judgements, categorized as low, medium, and high efficacy. The results revealed distinct neural signatures and behavioral patterns between the experimental conditions. Arousal levels predicted ratings of ritual efficacy.

Increased efficacy was marked by suppressed alpha and beta power, regardless of group or individual setting. In groups, efficacy ratings converged. Individual setting showed increased within-participant phase synchronization in alpha and beta bands, while group setting enhanced between-participant theta phase synchronization. This reflected group participants' orientation toward a common perspective and social coordination. These findings suggest that co-presence in groups leads to a social-tuning effect supported by between-participant theta phase synchrony. Together these neural synchrony patterns reveal how collective rituals have both individual and communal dimensions.

The emotionality of spirit-medium rituals drives individual perceptions of efficacy, while co-presence in groups signals the significance of an event and socially tunes enhanced agreement in perceptual ratings. In other words, mass gatherings may foster social cohesion without necessarily requiring group-size scaling limitations of direct face-to-face interaction. This could have implications for the scaling computability of synchrony in large groups as well as for humanistic studies in areas such as symbolic interactionism.

The article was published in: Frontiers in Psychology 9(2071).

Full article

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FIELD OF SCIENCE
Consciousness

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PUBLICATIONS

HARD PROBLEMS IN PHYSICS AND PHILOSOPHY OF MIND: DO THEY POINT TO SPIRITUALITY AS A SOLUTION?

Neuroscience, Consciousness and Spirituality, Springer

Info

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FIELD OF SCIENCE
Consciousness, Physics

I suggest that there exists an interesting and little known relationship between Neuroscience, Consciousness and Spirituality. To illustrate this, I first outline the paradoxical relation between the subjectivity of mind (i.e. consciousness) and its objective material correlate (i.e. neuroscience). I then give support to the notion that this paradox is rationally unsolvable by showing that it is isomorphic to the wave-particle paradox in quantum physics, where the impossibility to rationally resolve it has eventually been accepted as a fundamental property of reality, called the complementarity principle.

Next, I point out that spiritual (mystical) traditions have also arrived at very similar paradoxical descriptions of reality, which lends additional plausibility to the insights from quantum physics and philosophy of mind (and vice versa!). Finally, and most importantly, I suggest that since mystical practices offer ways to individually transcend logical paradoxa by developing non-dual, transrational states of consciousness, they may provide a solution to fundamental theoretical problems such as those outlined above and should thus be regarded as an indispensible part of any advanced research methodology.

The article was published in: Neuroscience, Consciousness and Spirituality, Springer. 1: 109-118.

Full article

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PUBLICATIONS

HEALING AND RITUAL IMAGINATION IN CHINESE MEDICINE: THE MULTIPLE INTERPRETATIONS OF ZHUYOU

East Asian Science, Technology, and Medicine 38

Info

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2015

FIELD OF SCIENCE
Biology, Foundations

In the Chinese medical corpus, ritual healing largely fell under the rubric of zhuyou to uncover and expel the unknown, imperceptible, and occult causes of illness. Often dealing with uncertain or incurable cases, zhuyou remained at the cutting-edge of contemporary medicine. For a rising medical elite after the Northern Song, zhuyou was the branch of medicine to flexibly incorporate and critique the variety of ritual therapies into orthodox practice.

Zhuyou employed prayer, incantations, talismans, gestures, and drugs in a nuanced clinical encounter to reveal the hidden root of disorder ranging from a blockage of qi, spirit possession, emotional imbalance, or loss of virtue. These rituals opened an imaginative space for therapeutic play where patients and healers could use spiritual proxies and props to address difficult emotions or issues that were often the hidden cause of affliction.

The development of zhuyou also reflected the changing role of ritual in the history of Chinese medicine and the exchanges among physicians, Daoist priests, and other ritual healers. The significance of ritual in Chinese medical history has largely remained unclear as most editions of medical classics republished since the early twentieth century excise relevant chapters and zhuyou manuscripts, until recently, were uncatalogued.

The article was published in: East Asian Science, Technology, and Medicine 38: 71-113.

Full article

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PUBLICATIONS

IDENTIFYING RESEARCH FACILITATORS IN AN EMERGING ASIAN RESEARCH AREA

Scientometrics 97(1)

We introduce a novel set of metrics for triadic closure among individuals or groups to model how co-authorship networks become more integrated over time. We call this process of triadic, third-party mediated integration, research facilitation. We apply our research facilitation or RF-metrics to the development of the Pan-Asian SNP (PASNP) Consortium, the first inter-Asian genomics network.

Our aim was to examine if the consortium catalyzed research facilitation or integration among the members and the wider region. The PASNP Consortium is an ideal case study of an emerging Asian Research Area because its members themselves asserted a regional Asian identity. To validate our model, we developed data mining software to extract and match full author and institutional information from the PDFs of scientific papers.

The article was published in: Scientometrics 97(1): 75-97.

Full article

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FIELD OF SCIENCE
Biology

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PUBLICATIONS

IMPLICATIONS OF A DEEPER LEVEL EXPLANATION OF THE DEBROGLIE–BOHM VERSION OF QUANTUM MECHANICS

Quantum Studies: Math. and Foundations 2(1)

Info

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FIELD OF SCIENCE
Physics

Elements of a "deeper level" explanation of the deBroglie-Bohm (dBB) version of quantum me- chanics are presented. Our explanation is based on an analogy of quantum wave-particle dual- ity with bouncing droplets in an oscillating medium, the latter being identified as the vacuum's zero-point field. A hydrodynamic analogy of a similar type has recently come under criticism by Richardson et al., because despite striking similarities at a phenomenological level the governing equations related to the force on the particle are evidently different for the hydrodynamic and the quantum descriptions, respectively.
However, said differences are not relevant if a radically different use of said analogy is being made, thereby essentially referring to emergent processes in our model. If the latter are taken into account, one can show that the forces on the particles are identical in both the dBB and our model. In particular, this identity results from an exact matching of our emergent velocity field with the Bohmian "guiding equation".
One thus arrives at an explanation involving a deeper, i.e. subquantum, level of the dBB version of quantum mechanics. We show in particular how the classically-local approach of the usual hydrodynamical modeling can be overcome and how, as a consequence, the configuration-space version of dBB theory for N particles can be completely substituted by a "superclassical" emergent dynamics of N particles in real 3-dimensional space.
The article was published in: Quantum Studies: Math. and Foundations 2(1): 133-140.

Full article

This work was supported (in part) by the Fetzer Franklin Fund of the John E. Fetzer Memorial Trust.

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PUBLICATIONS

INTERFERENCE ENERGY SPECTRUM OF THE INFINITE SQUARE WELL

Entropy 18(4)

Certain superposition states of the 1-D infinite square well have transient zeros at locations other than the nodes of the eigenstates that comprise them. It is shown that if an infinite potential barrier is suddenly raised at some or all of these zeros, the well can be split into multiple adjacent infinite square wells without affecting the wavefunction. This effects a change of the energy eigenbasis of the state to a basis that does not commute with the original, and a subsequent measurement of the energy now reveals a completely different spectrum, which we call the {interference energy spectrum} of the state.

This name is appropriate because the same splitting procedure applied at the stationary nodes of any eigenstate does not change the measurable energy of the state. Of particular interest, this procedure can result in measurable energies that are greater than the energy of the highest mode in the original superposition, raising questions about the conservation of energy akin to those that have been raised in the study of superoscillations.

An analytic derivation is given for the interference spectrum of a given wavefunction $\Psi(x,t)$ with N known zeros located at points $s_i = (x_i, t_i)$. Numerical simulations were used to verify that a barrier can be rapidly raised at a zero of the wavefunction without significantly affecting it. The interpretation of this result with respect to the conservation of energy and the energy-time uncertainty relation is discussed, and the idea of alternate energy eigenbases is fleshed out. The~question of whether or not a preferred discrete energy spectrum is an inherent feature of a particle's quantum state is examined.

The article was published in: Entropy 18(4): 149.

Full article

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FIELD OF SCIENCE
Physics

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PUBLICATIONS

INTERMITTENT VORTICITY, POWER SPECTRAL SCALING AND DYNAMICAL MEASURES ON RESTING BRAIN MAGNETIC FIELD FLUCTUATIONS

"The dynamic brain" - Oxford University Press

Info

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2011

FIELD OF SCIENCE
Biology

A new time-dependent global MEG variable, *symmetric sensor difference series*, from frontal, central, parietal and temporal sensor pairs in ten task free, resting schizophrenic patients and ten age and sex matched controls were studied using Morlet wavelet transformations of the leading eigenfunctions of correlation-time-lagged auto-covariance matrices, power spectral scaling indices, topological and metric entropies, unwinding numbers, leading Lyapounov exponents, capacity dimension, high moments and a product-measure order parameter, *measureable entropy manifold volume, memv.*

A new dynamical object with longest time scales in tens of seconds, the *strudel*, intermittent incidents of simultaneously hierarchical vorticity, was found in the wavelet graphs. Speculation arises that strudels may be concomitants of "task unrelated thoughts" or daydreaming. In this pilot study, episodes of absent and decreased strudel density and statistically significant lower values of *memv* and the other entropy-complexity measures were observed in schizophrenic patients *compared* with controls.

The article was published in: The dynamic brain Oxford University Press Oxford. 296-337.

Full article

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PUBLICATIONS

INTERPRETING WEAK VALUE AMPLIFICATION WITH A TOY REALIST MODEL

arXiv

Constructing an ontology for quantum theory is challenging, in part due to unavoidable measurement back-action. The Aharonov-Albert-Vaidman weak measurement formalism provides a method to predict measurement results (weak values) in a regime where back-action is negligible. The weak value appears analogous to a classical conditional mean and in fact, has a number of features that further suggest it may be interpreted as being related to some underlying ontological model.

However, the ontology appears bizarre since the weak values are complex and unbounded. Here, we study weak values in the context of a recent quantum optical experiment involving two-photon inter- actions. The results of the experiment are reinterpreted within a 'stochastic optics' model of light. The model is based on standard (Maxwell) electromag- netic theory, supplemented by stochastic fluctuations of the electromagnetic fields.

We show that the conditional means of the electric field intensities cor- respond to the experimentally observed weak values. This is a provocative result, as it suggests that at least within this experiment, the weak value gives us information about the average of an ontological quantity (the intensity). We study the breakdown of the stochastic optics model, which occurs outside the experimentally probed regime, and in particular in the limit where the weak value predicts 'anomalous' results.

The article was published in: arXiv:1808.09951v2, 27Mar2019

Full article

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YEAR
2018

FIELD OF SCIENCE
Physics

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PUBLICATIONS

INTRINSIC MODE FUNCTIONS LOCATE IMPLICIT TURBULENT ATTRACTORS IN TIME IN FRONTAL LOBE MEG RECORDINGS

Neuroscience 267

Info

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2014

FIELD OF SCIENCE
Physics

In seeking evidence for the presence and characteristic range of coupled time scale(s) of putative implicit turbulent attractors of dorsal frontal lobe magnetic fields, the recorded nonstationary, nonlinear MEG signals were non-orthogonally decomposed using Huang's Empirical Mode Decomposition, EMD, (Huang and Attoh-Okine, 2005) into 16 Intrinsic Mode Functions, EMD → IMFi, i = 1...16.

Measures known to be invariant in non-uniformly hyperbolic (turbulent) dynamical systems, topological entropy, hT, metric entropy, hM, non-uniform entropy, hU and power spectral scaling exponent, α, were imposed on each of the IMFi which evidenced most clearly an invariant temporal scale zone of IMFi, i = 6...11, for hT, which we have found to be the most robust of invariant measures of MEG's magnetic field turbulent attractors (Mandell et al., 2011a, Mandell et al., 2011b, Mandell, 2013).

The ergodic theory of dynamical systems (Walters, 1982, Pollicott and Yuri, 1998) allows the inference that an implicit attractor with consistently hT > 0 will also evidence at least one positive Lyapounov exponent indicating the presence of a turbulent attractor with exponential separation of nearby initial conditions, exponential convergence of distant points and disordering, mixing, of orbital sequences. It appears that this approach permits the inference of the presence of chaotic, turbulent attractor and its characteristic time scales without the invocation of arbitrary n-dimensional embedding, phase space reconstructions or (inappropriate) orthogonal decompositions.

The article was published in: Neuroscience 267: 91-101.

Full article

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PUBLICATIONS

INTRODUCTION: PROCESS THOUGHT, SCIENCE, AND PHILOSOPHY

World Futures - The Journal of New Paradigm Research, Volume 65

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YEAR
2009

FIELD OF SCIENCE
Physics

The dramatic success of science since the 17th century, documented in our first special issue introduction (Rifffert and Eastman, 2008), led to conditions that shifted the mantle of authority from religion to science, a shift that culminated with the achievements of Darwin and Einstein.

This same period witnessed the development of the classical view of nature, which incorporates a metaphysical framework that continues to have substantial influence as shown by its coupling with modern physics in the standard view of nature dominant throughout most of the 20th century (Eastman, 2008).

The article was published in: World Futures The Journal of New Paradigm Research Volume 65, 2009 - Issue 1: Process Thought, Science and Philosophy.

Full article

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PUBLICATIONS

IS THE WORLD LOCAL OR NONLOCAL? TOWARDS AN EMERGENT QUANTUM MECHANICS IN THE 21ST CENTURY.

Journal of Physics: Conference Series, Volume 701

What defines an emergent quantum mechanics (EmQM)? Can new insight be advanced into the nature of quantum nonlocality by seeking new links between quantum and emergent phenomena as described by self-organization, complexity, or emergence theory? Could the development of a future EmQM lead to a unified, relational image of the cosmos? One key motivation for adopting the concept of emergence in relation to quantum theory concerns the persistent failure in standard physics to unify the two pillars in the foundations of physics: quantum theory and general relativity theory (GRT).

The total contradiction in the foundational, metaphysical assumptions that define orthodox quantum theory versus GRT might render inter-theoretic unification impossible. On the one hand, indeterminism and non-causality define orthodox quantum mechanics, and, on the other hand, GRT is governed by causality and determinism. How could these two metaphysically-contradictory theories ever be reconciled? The present work argues that metaphysical contradiction necessarily implies physical contradiction.

The contradictions are essentially responsible also for the measurement problem in quantum mechanics. A common foundation may be needed for overcoming the contradictions between the two foundational theories. The concept of emergence, and the development of an EmQM, might help advance a common foundation - physical and metaphysical - as required for successfull inter-theory unification.

The article was published in:Journal of Physics: Conference Series, Volume 701, conference 1

Full article

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YEAR
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FIELD OF SCIENCE
Physics

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PUBLICATIONS

KEY ROLE OF ALKALINE PHOSPHATASE IN THE DEVELOPMENT OF HUMAN-DERIVED NANOPARTICLES IN VITRO

Acta biomaterialia 7(3)

Alkaline phosphatase (ALP) is an enzyme critical for physiological and pathological biomineralization. Experiments were designed to determine whether ALP participates in the formation of calcifying nanometer sized particles (NPs) in vitro. Filtered homogenates of human calcified carotid artery, aorta and kidney stones were inoculated into cell culture medium containing 10% fetal bovine serum in the absence or presence of inhibitors of ALP or pyrophosphate.

A calcific NP biofilm developed within 1 week after inoculation and their development was reduced by pyrophosphate and inhibitors of ALP. ALP protein and enzymatic activity were detected in washed NPs, whether calcified or decalcified. Therefore, ALP activity is required for the formation of calcifying NPs in vitro, as has previously been implicated during pathological calcification in vivo.

The article was first published in: Acta biomaterialia 7(3): 1339-1345.

Full article

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2011

FIELD OF SCIENCE
Biology

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PUBLICATIONS

LOCALIZING AND OBSERVING KOCHEN-SPECKER QUANTUM CONTEXTUALITY USING WEAK MEASUREMENTS

Proceedings of: 'APS Meeting Abstracts'

Experimental tests of the Kochen-Specker (KS) theorem conventionally require a set of different measurement settings, and the test can furthermore be applied to an arbitrary prepared state. These experiments show that nature is contextual, but they do not indicate which specific observables must behave nonclassically. We show that, using pre- and post-selected states from within a set of projectors that prove the KS theorem, it is possible to identify another specific projector in the set that behaves nonclassically, in this case because it has an anomalous weak value.

We explore specific KS sets that gives rise to the Quantum Pigeonhole Effect (QPE), and use weak measurements on a large ensemble of identically pre- and post-selected neutrons to verify the QPE, and also to measure the anomalous weak value of the nonclassical projector. We construct a new contextuality inequality based on the recent result of Pusey showing that any projector with a negative weak value is a proof of contextuality, and show that our measured weak value is many standard deviations below zero.

The article was published in: Proceedings of: 'APS Meeting Abstracts'.

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2016

FIELD OF SCIENCE
Physics

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PUBLICATIONS

MAPPING COMPLEX MIND STATES: EEG NEURAL SUBSTRATES OF MEDITATIVE UNIFIED COMPASSIONATE AWARENESS

Consciousness and cognition 57

Info

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YEAR
2018

FIELD OF SCIENCE
Consciousness, Physics

Specific mental training cultivates diminished self-reference, encompassing non-duality, emptiness, awakened-awareness, and compassionate experiences. We aimed to elucidate the neural substrates of four distinct, interdependent *Essence-of-Mind* states: (1) timelessness, (2) non-preference, non-duality, non-conceptualization, (3) the view of luminosity and limitlessness, (4) unified compassionate experience of oneness (stable awakened-awareness).

EEG data were collected from 30 advanced meditators concomitant to eyes-open/eyes-closed resting baseline, followed by 60-min of instructed practice. Alpha, beta, and gamma, frequency-spatial EEG-dimensions were analyzed. The results revealed that compared to baseline, current density across frequencies significantly decreased upon meditation onset in self-referential, and executive-control regions.

During meditation, gamma-band current density significantly increased from state-1 compared to state-4, within the ACC, precuneus, and superior parietal lobule, whereas beta-band activity increased within the insula. These findings suggest a dissociation between brain regions regulating self-referential vs. executive-control processing, during non-dual, compassionate states, characterized by brilliantly awake awareness, free from conceptual thought and "doing".

The article was published in: Consciousness and cognition 57: 41-53.

Full article

This work was supported (in part) by the Fetzer Franklin Fund of the John E. Fetzer Memorial Trust.

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PUBLICATIONS

MEASURES FROM NONLINEAR DYNAMICS REFLECT GLUCOSE CURRENT SENSOR DEGRADATION

'International Conference on Applications in Nonlinear Dynamics'

Info

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YEAR
2016

FIELD OF SCIENCE
Physics

Advancements in continuous glucose monitoring technology has enabled development of closed-loop insulin-glucagon delivery systems. Monitoring the reliability and fidelity of glucose current, () Σ I g (t) , becomes essential for the safety of patients utilizing these closed loop systems (Barnaba et al., Diab Technol Ther 5:27-31, 2005).

Because time series of () Σ I g (t) evidence chaotic nonlinear hyperbolic (expanding and mixing) dynamical behavior (Ruelle and Takens, Commun Math Phys 20(3):167-192, 1971) [10], we use the complexity measures from dynamical measure theory to discriminate normal function from progressive dysfunction in glucose sensors (Cornfeld et al., Ergodic Theory, 2012).

We present a method of characterizing the () Σ I g (t) from the continuous glucose monitor signal, CGM, using a set of entropy equivalent information measures (EEIM) that, when combined with the use of a support vector machine, were found to distinguish between functional and failing continuous glucose sensors.

The article was published in: Proceedings of: 'International Conference on Applications in Nonlinear Dynamics', Springer: 189-193.

Full article

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PUBLICATIONS

MEASURING THE PAST OF QUANTUM SYSTEMS: FROM COUNTING QUANTUM PIGEONS TO WATCHING ATOMS AS THEY TUNNEL

APS March Meeting 2018', Harvard University

Info

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YEAR
2018

FIELD OF SCIENCE
Physics

In quantum mechanics, as in the classical world, one can draw some conclusions from present observations about the past behaviour of a system. The question of just what one can say about a system given knowledge of its preparation and its final state remains a topic of discussion. I will present a number of recent and ongoing experiments which address these issues by applying weak measurements (in the sense of Aharonov, Albert, and Vaidman) and post-selected strong measurements (à la Aharonov, Bergmann, and Lebowitz) to systems ranging from entangled photons to tunneling atoms to quantum-level laser beams interacting through an optical nonlinearity.

Such measurements offer insight into processes such as tunneling, but are also well known to lead to some results which violate our intuitive expectations. Applying variable-strength measurements to the "pigeonhole paradox" will allow us to probe just how certain aspects of these "conditional measurements" remain robust, independent of measurement strength, while other axioms and sum rules behave quite differently in different regimes. I will also discuss how a weak measurement of photon number may exceed the number of prepared photons, and what weak measurements tell us about where particles "spend their time" while tunneling through a barrier.

The paper was presented at: 'APS March Meeting 2018', Harvard University.

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PUBLICATIONS

MEASURING THE TIME A TUNNELLING ATOM SPENDS IN THE BARRIER

arXiv

Info

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YEAR
2019

FIELD OF SCIENCE
Physics

Tunnelling is one of the most paradigmatic and evocative phenomena of quantum physics, underlying processes such as photosynthesis and nuclear fusion, as well as devices ranging from SQUID magnetometers to superconducting qubits for quantum computers. The question of how long a particle takes to tunnel, however, has remained controversial since the first attempts to calculate it, which relied on the group delay. It is now well understood that this delay (the arrival time of the transmitted wave packet peak at the far side of the barrier) can be smaller than the barrier thickness divided by the speed of light, without violating causality.

There have been a number of experiments confirming this, and even a recent one claiming that tunnelling may take no time at all. There have also been efforts to identify another timescale, which would better describe how long a given particle spends in the barrier region. Here we present a direct measurement of such a time, studying Bose-condensed ^{87}Rb atoms tunnelling through a 1.3-${\mu}$m thick optical barrier. By localizing a pseudo-magnetic field inside the barrier, we use the spin precession of the atoms as a clock to measure the time it takes them to cross the classically forbidden region.

We find a traversal time of 0.62(7) ms and study its dependence on incident energy. In addition to finally shedding light on the fundamental question of the tunnelling time, this experiment lays the groundwork for addressing deep foundational questions about history in quantum mechanics: for instance, what can we learn about where a particle was at earlier times by observing where it is now?

The article was published in: arXiv preprint arXiv:1907.13523.

Full article

This work was supported (in part) by the Fetzer Franklin Fund of the John E. Fetzer Memorial Trust.

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PUBLICATIONS

METASCIENCE – THE SCIENCE OF DOING SCIENCE

Association for Psychological Science

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YEAR
2019

FIELD OF SCIENCE
Foundations

The field of metascience has gained increasing momentum in recent years as concerns about research reproducibility have fueled a larger vision of how the lens of science can be directed toward the scientific process itself. Metascience, also known as metaresearch or the science of science, attempts to use quantifiable scientific methods to elucidate how science works and why it sometimes fails.

Metascience has its roots in the philosophy of science and the study of scientific methods. However, it is distinguished from the former by its reliance on quantitative analysis and from the latter by its broad focus on the general factors that contribute to all aspects of the scientific process. Metascience also draws on the more narrowly defined fields of journalology, which studies the academic publishing process, and scientometrics, which uses bibliographic data in scientific publications to understand the impact of research articles.

Full article

This work was supported (in part) by the Fetzer Franklin Fund.

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PUBLICATIONS

MINIMAL COMPLEXITY OF KOCHEN-SPECKER SETS DOES NOT SCALE WITH DIMENSION

Physical Review A 95(5)

A Kochen-Specker (KS) set is a specific set of projectors and measurement contexts that prove the Bell- Kochen-Specker contextuality theorem. The simplest known KS sets in Hilbert space dimensions d = 3, 4, 5, 6, 8 are reproduced, and several methods by which a new KS set can be constructed using one or more known KS sets in lower dimensions are reviewed and improved. These KS sets and improved methods enable the construction of explicitly critical new KS sets in all dimensions, where critical refers to the irreducibility of the set of contexts.
The simplest known critical KS sets are derived in all even dimensions d ≥ 10 with at most 9 contexts and 30 projectors, and in all odd dimensions d ≥ 7 with at most 13 contexts and 39 projectors. These results show that neither the number of contexts nor the number of projectors in a minimal KS set scales with dimension d.
The article was published in: Physical Review A 95(5): 050101

This work was supported (in part) by the Fetzer Franklin Fund of the John E. Fetzer Memorial Trust.

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YEAR
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FIELD OF SCIENCE
Physics

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PUBLICATIONS

MODELLING DOUBLE SLIT INTERFERENCE VIA ANOMALOUS DIFFUSION: INDEPENDENTLY VARIABLE SLIT WIDTHS

arXiv

Info

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YEAR
2013

FIELD OF SCIENCE
Physics

Based on a re-formulation of the classical explanation of quantum mechanical Gaussian dispersion (Groessing et al. 2010) as well as interference of two Gaussians (Groessing et al. 2012), we present a new and more practical way of their simulation. The quantum mechanical "decay of the wave packet" can be described by anomalous sub-quantum diffusion with a specific diffusivity varying in time due to a particle's changing thermal environment. In a simulation of the double-slit experiment with different slit widths, the phase with this new approach can be implemented as a local quantity.

We describe the conditions of the diffusivity and, by connecting to wave mechanics, we compute the exact quantum mechanical intensity distributions, as well as the corresponding trajectory distributions according to the velocity field of two Gaussian wave packets emerging from a double-slit. We also calculate probability density current distributions, including situations where phase shifters affect a single slit's current, and provide computer simulations thereof.

The article was published in: arXiv preprint arXiv: 1304.2885.

Full article

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PUBLICATIONS

MODELLING QUANTUM MECHANICAL DOUBLE SLIT INTERFERENCE VIA ANOMALOUS DIFFUSION: INDEPENDENTLY VARIABLE SLIT WIDTHS

Physica A: Statistical Mechanics and its Applications

Info

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FIELD OF SCIENCE
Physics

Based on a re-formulation of the classical explanation of quantum mechanical Gaussian dispersion (Groessing et al. 2010) as well as interference of two Gaussians (Groessing et al. 2012), we present a new and more practical way of their simulation. The quantum mechanical "decay of the wave packet" can be described by anomalous sub-quantum diffusion with a specific diffusivity varying in time due to a particle's changing thermal environment.

In a simulation of the double-slit experiment with different slit widths, the phase with this new approach can be implemented as a local quantity. We describe the conditions of the diffusivity and, by connecting to wave mechanics, we compute the exact quantum mechanical intensity distributions, as well as the corresponding trajectory distributions according to the velocity field of two Gaussian wave packets emerging from a double-slit. We also calculate probability density current distributions, including situations where phase shifters affect a single slit's current, and provide computer simulations thereof.

The article was published in: Physica A: Statistical Mechanics and its Applications 392(12): 2718-2727.

Full article

This work was supported (in part) by the Fetzer Franklin Fund of the John E. Fetzer Memorial Trust.

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PUBLICATIONS

MONTE-CARLO SIMULATION TO REDUCE SENSOR DIMENSION OF EEG NEUROFEEDBACK DEVICE

APS Meeting Abstracts'

Info

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YEAR
2019

FIELD OF SCIENCE
Biology, Consciousness

Neuro-feedback (NF) training using EEG device is finding wide acceptance for treatment of ADHD, epilepsy, anxiety, dyslexia, schizophrenia etc. In realistic clinical practice, high quality delivery of NF signal is possible only with high sensor density devices.

Unfortunately, these are often cost-prohibitive, time consuming and unmanageable due to large number of sensors. So, reduction of sensor dimension without compromising the quality of the signal is an important clinical problem. On the contrary, inexpensive low density devices lacks clinical precision. This can be solved by generating reduced dimension sensor configuration by Monte Carlo (MC) sampling of high-quality data. In our experiment, high quality EEG data was collected from NF sessions with 72 subjects.

MC sampling of all possible 32 configurations were used to generate a targeted set of montages to produce NF source signal equivalent to those from the original high-density configuration. We found a large pool of potential montage configurations with only 32 sensors that can reproduce results from high density sensor system with more than 80%. Thus, MC sampling can be utilized to design low cost clinical grade EEG devices without compromising the quality.

The paper was published at: *Proceedings of: 'APS Meeting Abstracts'*.

Full paper

This work was supported (in part) by the Fetzer Franklin Fund of the John E. Fetzer Memorial Trust.

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PUBLICATIONS

MUTUAL INFORMATION IN A MEG COMPLEXITY MEASURE SUGGESTS REGIONAL HYPER-CONNECTIVITY IN SCHIZOPHRENIC PROBANDS

Neuropsychopharmacology 40

Info

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YEAR
2014

FIELD OF SCIENCE
Biology, Physics

Abnormalities of regional brain functional connectivity have been suggested for the syndromes of schizophrenia since the origin of the name using the Greek roots: skhizein (to split) and phren (mind) by Eugen Bleuler in 1908 (Kuhn, 2004). The neuropsychologist Norman Geschwind generalized this pathophysiological concept in his classic papers about what he called the disconnexion syndromes (Geschwind, 1965).

He suggested that deficits in higher functions resulted from the disruption of pathways involving the signal relay functions of the association cortices. Discontinuities in white matter observed in diffusion tensor imaging and inferences from fMRI have been interpreted as evidence for cortical network disconnections in patients with schizophrenia (Bullmore et al, 1997).

The article was published in: Neuropsychopharmacology 40: 251

Full article

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PUBLICATIONS

NON-CLASSICAL CORRELATIONS IN BISTABLE PERCEPTION?

Axiomathes 21(2)

A violation of Bell's inequalities is generally considered to be the Holy Grail of experimental proof that a specific natural phenomenon cannot be explained in a classical framework and is based on a non-boolean structure of predications. Generalized quantum theory allows for such non-boolean predications. We formulate temporal Bell's inequalities for cognitive two-state systems and indicate how these inequalities can be tested. This will introduce the notion of temporally non-local measurements. The Necker-Zeno model for bistable perception predicts a violation of these temporal Bell's inequalities.

The article was published in: Axiomathes 21(2): 221-232.

Full article

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YEAR
2011

FIELD OF SCIENCE
Physics

Back to Publications

PUBLICATIONS

NONCONTEXTUALITY INEQUALITIES FROM ANTIDISTINGUISHABILITY

APS Meeting Abstracts

Noncontextuality inequalities are usually derived from the distinguishability properties of quantum states, i.e. their orthogonality. Here, we show that antidistinguishability can also be used to derive noncontextuality inequalities. Briefly, a set of states can be antidistinguished if there exists a measurement on the basis of which one can exclude one of the states as definitely not having been prepared.

The Yu-Oh 13 ray contextuality inequality can be rederived and generalized as an instance of our antidistinguishability method. For some sets of states, the antidistinguishability method gives tighter bounds on noncontextual models than just considering orthogonality, and the Hadamard states provide an example of this. Antidistiguishability-based inequalities were initially discovered as overlap bounds for the reality of the quantum state. Our main contribution here is to show that they are also noncontextuality inequalities.

The article was published in: Proceedings of: 'APS Meeting Abstracts'.

Full article

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YEAR
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FIELD OF SCIENCE
Physics

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PUBLICATIONS

NONEQUILIBRIUM ABUNDANCES FOR THE BUILDING BLOCKS OF LIFE

Physical Review E 99(5)

The difficulty of obtaining appreciable quantities of biologically important molecules in thermodynamic equilibrium has long been identified as an obstacle to life's emergence, and determining the specific nonequilibrium conditions that might have given rise to life is challenging. To address these issues, we investigate how the concentrations of life's building blocks change as a function of the distance from equilibrium *on average*, in two example settings: (i) the synthesis of heavy amino acids and (ii) their polymerization into peptides.

We find that relative concentrations of the heaviest amino acids can be boosted by four orders of magnitude, and concentrations of the longest peptide chains can be increased by hundreds of orders of magnitude. The average nonequilibrium distribution does not depend on the details of how the system was driven from equilibrium, indicating that environments might not have to be fine-tuned to support life.

The article was published in: Physical Review E 99(5): 052101.

Full article

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YEAR
2019

FIELD OF SCIENCE
Biology, Physics

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PUBLICATIONS

NONLINEAR SCHRÖDINGER EQUATION IN FOUNDATIONS: SUMMARY OF 4 CATCHES

Journal of Physics: Conference Series

Info

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YEAR
2016

FIELD OF SCIENCE
Physics

Fundamental modifications of the standard Schrödinger equation by additional nonlinear terms have been considered for various purposes over the recent decades. It came as a surprise when, inverting Abner Shimonyi's observation of "peaceful coexistence" between standard quantum mechanics and relativity, N. Gisin proved in 1990 that any (deterministic) nonlinear Schrödinger equation would allow for superluminal communication. This is by now the most spectacular and best known fundational anomaly. I am going to discuss further anomalies, simple but foundational, less spectacular but not less dramatic.
The article was published in: Proceedings of: 'Journal of Physics: Conference Series', IOP Publishing: 012019.

Full article

This work was supported (in part) by the Fetzer Franklin Fund of the John E. Fetzer Memorial Trust.

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PUBLICATIONS

NONLOCAL EFFECTS INDUCED BY THE PHASE OF THE SCHRÖDINGER WAVEFUNCTION FOR A PARTICLE IN A CAVITY WITH MOVING BOUNDARIES

arXiv

We investigate the dynamics of a particle in a confined periodic system — a time-dependent oscillator confined by infinitely high and moving walls — and focus on the evolution of the phase of the wavefunction. It is shown that for some specific initial states in this potential, the phase evolves nonlocally. We further elaborate a thought experiment devised to detect this form of single-particle nonlocality.

We point out that within the non-relativistic formalism based on the Schrödinger equation (SE), detecting this form of nonlocality can give rise to signaling. We believe this effect is an artifact, but the standard relativistic corrections to the SE do not appear to fix it. Specific illustrations are given, with analytical results in the adiabatic approximation, and numerical computations to show that contributions from high-energy states (corresponding to superluminal velocities) are negligible.

The article was published in: arXiv preprint arXiv:1909.06465.

Full article

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YEAR
2019

FIELD OF SCIENCE
Physics

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PUBLICATIONS

NONLOCAL QUANTUM INFORMATION TRANSFER WITHOUT SUPERLUMINAL SIGNALLING AND COMMUNICATION

Foundations of Physics 46(9)

Info

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YEAR
2016

FIELD OF SCIENCE
Physics

It is a frequent assumption that – via superluminal information transfers – superluminal signals capable of enabling communication are necessarily exchanged in any quantum theory that posits hidden superluminal influences. However, does the presence of hidden superluminal influences automatically imply superluminal signalling and communication? The non-signalling theorem mediates the apparent conflict between quantum mechanics and the theory of special relativity. However, as a 'no-go' theorem there exist two opposing interpretations of the non-signalling constraint: foundational and operational. Concerning Bell's theorem, we argue that Bell employed both interpretations, and that he finally adopted the operational position which is associated often with ontological quantum theory, e.g., de Broglie–Bohm theory. This position we refer to as "effective non-signalling". By contrast, associated with orthodox quantum mechanics is the foundational position referred to here as "axiomatic non-signalling". In search of a decisive communication-theoretic criterion for differentiating between "axiomatic" and "effective" non-signalling, we employ the operational framework offered by Shannon's mathematical theory of communication, whereby we distinguish between Shannon signals and non-Shannon signals. We find that an effective non-signalling theorem represents two sub-theorems: (1) Non- transfer-control (NTC) theorem, and (2) Non-signification-control (NSC) theorem. Employing NTC and NSC theorems, we report that effective, instead of axiomatic, non-signalling is entirely sufficient for prohibiting nonlocal communication. Effective non-signalling prevents the instantaneous, i.e., superluminal, transfer of message-encoded information through the controlled use – by a sender-receiver pair – of informationally-correlated detection events, e.g., in EPR-type experiments. An effective non-signalling theorem allows for nonlocal quantum information transfer yet – at the same time – effectively denies superluminal signalling and communication.

The article was published in: Foundations of Physics 46(9): 1208-1228.

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This work was supported (in part) by the Fetzer Franklin Fund of the John E. Fetzer Memorial Trust.

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PUBLICATIONS

NONLOCALITY AND LOCAL CAUSALITY IN THE SCHRÖDINGER EQUATION WITH TIME-DEPENDENT BOUNDARY CONDITIONS

Physics Letters A 382(46)

We investigate the nonlocal dynamics of a single particle placed in an infinite well with moving walls. It is shown that in this situation, the Schr¨odinger equation (SE) violates local causality by causing instantaneous changes in the probability current everywhere inside the well. This violation is formalized by designing a gedanken faster-than-light communication device which uses an ensemble of long narrow cavities and weak measurements to resolve the weak value of the momentum far away from the movable wall.

Our system is free from the usual features causing nonphysical violations of local causality when using the (nonrelativistic) SE, such as instantaneous changes in potentials or states involving arbitrarily high energies or velocities. We explore in detail several possible artifacts that could account for the failure of the SE to respect local causality for systems involving time-dependent boundary conditions.

The article was published in: Physics Letters A 382(46): 3347-3354.

Full article

This work was supported (in part) by the Fetzer Franklin Fund of the John E. Fetzer Memorial Trust.

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YEAR
2018

FIELD OF SCIENCE
Physics

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PUBLICATIONS

OBSERVATION OF A LARGE, RESONANT, CROSS-KERR NONLINEARITY IN A FREE-SPACE RYDBERG MEDIUM

arXiv

We report the experimental observation of a cross-Kerr nonlinearity in a free-space medium based on resonantly-excited, interacting Rydberg atoms and electromagnetically induced transparency. The nonlinearity is used to implement cross-phase modulation between two optical pulses. The nonlinear phase written onto the (3) −822 probe pulse is measured to be as large as 8 mrad per nW of signal power, corresponding to a χ of 10 m /V . Potential applications range from optical quantum information processing to quantum non-demolition measurement of photon number.

The article was published in: arXiv preprint arXiv:1906.05151.

Full article

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YEAR
2019

FIELD OF SCIENCE
Physics

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PUBLICATIONS

OBSERVING QUANTUM TRAJECTORIES: FROM MOTT'S PROBLEM TO QUANTUM ZENO EFFECT AND BACK

Annals of Physics 374

The experimental results of Kocsis et al., Mahler et al. and the proposed experiments of Morley et al. show that it is possible to construct "trajectories" in interference regions in a two-slit interferometer. These results call for a theoretical re-appraisal of the notion of a "quantum trajectory" first introduced by Dirac and in the present paper we re-examine this notion from the Bohm perspective based on Hamiltonian flows.

In particular, we examine the short-time propagator and the role that the quantum potential plays in determining the form of these trajectories. These trajectories differ from those produced in a typical particle tracker and the key to this difference lies in the active suppression of the quantum potential necessary to produce Motttype trajectories. We show, using a rigorous mathematical argument, how the active suppression of this potential arises. Finally we discuss in detail how this suppression also accounts for the quantum Zeno effect.

The article was published in: Annals of Physics 374: 190-211.

Full article

This work was supported (in part) by the Fetzer Franklin Fund of the John E. Fetzer Memorial Trust.

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YEAR
2016

FIELD OF SCIENCE
Physics

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PUBLICATIONS

OPTIMAL NONCLASSICALITY-BASED BENCHMARKS FOR LINEAR QUBIT ARRAYS

APS March Meeting 2018

Info

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YEAR
2018

FIELD OF SCIENCE
Physics

A special class of sets of M ≤N + 1 mutually commuting N-qubit Pauli operators can be used to simultaneously witness N-partite entanglement, violate a Bell inequality associated with the N-qubit Greenberger-Horne-Zeilinger theorem, and place a tight lower bound on the fidelity of particular stabilizer state preparations. This fidelity bound is tight in the sense that if the true fidelity is 1, then the lower bound obtained from M measurement settings also goes to 1, but it grows worse as the true fidelity degrades.

Example sets are given for N= 3,...,9 qubits, along with the corresponding circuit designs, which are optimized to require only nearest-neighbor controlled-Z operations on a linear array of physical qubits, with a uniform gate depth of four - local rotations to initialize each qubit, two rounds of staggered nearest neighbor controlled-Z gates, and local rotations to set the readout basis. These circuits were simulated to estimate their practicality with a range of state-of-the art T_1 decoherence times, T_2 dephasing times, and gate fidelities.

The paper was presented at: Proceedings of: 'APS March Meeting 2018, abstract id.L28.012

This work was supported (in part) by the Fetzer Franklin Fund of the John E. Fetzer Memorial Trust.

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PUBLICATIONS

OPTIMAL STOCHASTIC MODELING WITH UNITARY QUANTUM DYNAMICS

Physical Review A 99(6)

Identifying and extracting the past information relevant to the future behaviour of stochastic processes is a central task in the quantitative sciences. Quantum models offer a promising approach to this, allowing for accurate simulation of future trajectories whilst using less past information than any classical counterpart. Here we introduce a class of phase-enhanced quantum models, representing the most general means of causal simulation with a unitary quantum circuit.

We show that the resulting constructions can display advantages over previous state-of-art methods – both in the amount of information they need to store about the past, and in the minimal memory dimension they require to store this information.

Moreover, we find that these two features are generally competing factors in optimisation – leading to an ambiguity in what constitutes the optimal model – a phenomenon that does not manifest classically. Our results thus simultaneously offer new quantum advantages for stochastic simulation, and illustrate further qualitative differences in behaviour between classical and quantum notions of complexity.

The article was published in: *Physical Review A* 99(6): 062110.

Full article

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YEAR
2018

FIELD OF SCIENCE
Physics

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YEAR
2014

FIELD OF SCIENCE
Physics

Back to Publications

PUBLICATIONS

ORDER EFFECTS IN DYNAMIC SEMANTICS

Topics in cognitive science 6(1)

In their target article, Wang and Busemeyer (2013) discuss question order effects in terms of incompatible projectors on a Hilbert space. In a similar vein, Blutner recently presented an orthoalgebraic query language essentially relying on dynamic update semantics.

Here, I shall comment on some interesting analogies between the different variants of dynamic semantics and generalized quantum theory to illustrate other kinds of order effects in human cognition, such as belief revision, the resolution of anaphors, and default reasoning that result from the crucial non-commutativity of mental operations upon the belief state of a cognitive agent.

The article was published in: Topics in cognitive science 6(1): 67-73

Full article

This work was supported (in part) by the Fetzer Franklin Fund of the John E. Fetzer Memorial Trust.

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PUBLICATIONS

PHYSICS AND SPECULATIVE PHILOSOPHY

Physics and Speculative Philosophy: Potentiality in Modern Science

Info

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YEAR
2016

FIELD OF SCIENCE
Foundations, Physics

Through both an historical and philosophical analysis of the concept of possibility, we show how including both potentiality and actuality as part of the real is both compatible with experience and contributes to solving key problems of fundamental process and emergence.

The book is organized into four main sections that incorporate our routes to potentiality:

(1) potentiality in modern science [history and philosophy; quantum physics and complexity];

(2) Relational Realism [ontological interpretation of quantum physics; philosophy and logic];

(3) Process Physics [ontological interpretation of relativity theory; physics and philosophy];

(4) on speculative philosophy and physics [limitations and approximations; process philosophy].

We conclude that certain fundamental problems in modern physics require complementary analyses of certain philosophical and metaphysical issues, and that such scholarship reveals intrinsic features and limits of determinism, potentiality and emergence that enable, among others, important progress on the quantum theory of measurement problem and new understandings of emergence.

The article was published in: Physics and Speculative Philosophy: Potentiality in Modern Science 27: 1.

Full article

This work was supported (in part) by the Fetzer Franklin Fund of the John E. Fetzer Memorial Trust.

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PUBLICATIONS

PRE-COMMITMENT AND UPDATING BELIEFS

University of Virginia: PhD Dissertation

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YEAR
2019

FIELD OF SCIENCE
Consciousness

Beliefs help individuals make predictions about the world. When those predictions are incorrect, it may be useful to update beliefs. However, motivated cognition and biases (notably, hindsight bias and confirmation bias) can instead lead individuals to reshape interpretations of new evidence to seem more consistent with prior beliefs.

Pre-committing to a prediction or evaluation of new evidence before knowing its results may be one way to reduce the impact of these biases and facilitate belief updating. I first examined this possibility by having participants report predictions about their performance on a challenging anagrams task before or after completing the task. Relative to those who reported predictions after the task, participants who pre-committed to predictions reported predictions that were more discrepant from actual performance and updated their beliefs about their verbal ability more (Studies 1a and 1b).

The effect on belief updating was strongest among participants who directly tested their predictions (Study 2) and belief updating was related to their evaluations of the validity of the task (Study 3). Furthermore, increased belief updating seemed to not be due to faulty or shifting memory of initial ratings of verbal ability (Study 4), but rather reflected an increase in the discrepancy between predictions and observed outcomes (Study 5).

In a final study (Study 6), I examined pre-commitment as an intervention to reduce confirmation bias, finding that pre-committing to evaluations of new scientific studies eliminated the relation between initial beliefs and evaluations of evidence while also increasing belief updating. Together, these studies suggest that pre-commitment can reduce biases and increase belief updating in light of new evidence.

University of Virginia, PhD Dissertation published in: PsyArXiv Preprints

Full dissertation

This work was supported (in part) by the Fetzer Franklin Fund of the John E. Fetzer Memorial Trust.

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PUBLICATIONS

PROTEOMIC EVALUATION OF BIOLOGICAL NANOPARTICLES ISOLATED FROM HUMAN KIDNEY STONES AND CALCIFIED ARTERIES

Acta Biomater. 2010 Oct; 6(10)

Info

AUTHORS
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YEAR
2010

FIELD OF SCIENCE
Biology

Calcifying biological nanoparticles (NPs) develop under cell culture conditions from homogenates of diverse tissue samples displaying extraosseous mineralization, including kidney stones and calcified aneurysms. Probes to definitively identify NPs in biological systems are lacking. Therefore, the aim of this study was to begin to establish a proteomic biosignature of NPs in order to facilitate more definitive investigation of their contribution to disease. Biological NPs derived from human kidney stones and calcified aneurysms were completely decalcified by overnight treatment with ethylenediaminetetraacetic acid or brief incubation in HCl, as evidenced by lack of a calcium shell and of Alizarin Red S staining, by transmission electron microscopy and confocal microscopy, respectively.

Decalcified NPs contained numerous proteins, including some from bovine serum and others of prokaryotic origin. Most prominent of the latter group was EF-Tu, which appeared to be identical to EF-Tu from Staphylococcus epidermidis. A monoclonal antibody against human EF-Tu recognized a protein in Western blots of total NP lysate, as well as in intact NPs by immunofluorescence and immunogold EM.

Approximately 8% of NPs were quantitatively recognized by the antibody using flow cytometry. Therefore, we have defined methods to reproducibly decalcify biological NPs, and identified key components of their proteome. These elements, including EF-Tu, can be used as biomarkers to further define the processes that mediate propagation of biological NPs and their contribution to disease.

The article was published in: Acta Biomater. 2010 Oct; 6(10): 4065-4072.

Full article

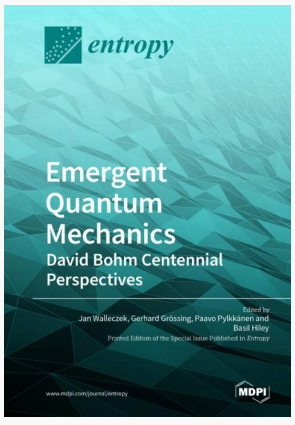
This work was supported (in part) by the Fetzer Franklin Fund of the John E. Fetzer Memorial Trust.

PUBLICATIONS

This list of publications covers work that was performed with the support of the Fetzer Franklin Fund of the John E. Fetzer Memorial Trust. These publications represent research findings from the four different goal areas of funded research at the Fetzer Franklin Fund: Physics, metascience, consciousness research, and biology.

For better access, the search function can be used to identify different authors and keywords in the title. The list is not exhaustive and more publications will be added in the future.

FEATURED



EMERGENT QUANTUM MECHANICS – DAVID BOHM CENTENNIAL PERSPECTIVES

Emergent quantum mechanics (EmQM) explores the possibility of an ontology for quantum mechanics. The resurgence of interest in realist approaches to quantum mechanics challenges the standard textbook view, which represents an operationalist approach. The possibility of an ontological, i.e., realist, quantum mechanics was first introduced with the original de Broglie-Bohm theory, which has also been developed in another context as Bohmian mechanics. This book features expert contributions which were invited as part of the David Bohm Centennial symposium of the EmQM conference series.

More

METASCIENCE – THE SCIENCE OF DOING SCIENCE

Metascience has its roots in the philosophy of science and the study of scientific methods. However, it is distinguished from the former by its reliance on quantitative analysis and from the latter by its broad focus on the general factors that contribute to all aspects of the scientific process.

More

FALSE-POSITIVE EFFECT IN THE RADIN DOUBLE-SLIT EXPERIMENT ON OBSERVER CONSCIOUSNESS AS DETERMINED WITH THE ADVANCED META-EXPERIMENTAL PROTOCOL (AMP)

Prior work by Radin et al. (2012, 2016) reported the astonishing claim that an anomalous effect on double-slit (DS) light-interference intensity had been measured as a function of quantum-based observer consciousness. Given the radical implications, could there exist an alternative explanation, other than an anomalous consciousness effect, such as artifacts including systematic methodological error (SME)? To address this question, a conceptual replication study involving 10,000 test trials was commissioned to be performed blindly by the same investigator who had reported the original results.

More

FILTER THE ARCHIVE

Choose field of science: Biology Consciousness Foundations Physics

Publishing year: **All** | 2019 | 2018 | 2017 | 2016 | 2015 | 2014 | 2013 | 2012 | 2011 | 2010 | 2009 | 2008 | 2006

AUTHORS	PROJECT TITLE	YEAR	FIELD OF SCIENCE
Goldwater, D., Barker, P., Bassi, A., Donadi, S.	A Quantum Spectrometer for Arbitrary Noise	2019	Physics
Walleczek, J.	Agent Inaccessibility as a Fundamental Principle in Quantum Mechanics: Objective Unpredictability and Formal Uncomputability	2019	Physics
Evers, E.; O'Donnell, M.; Inbar, Y.	Arbitrary Fairness in Rewards and Punishments	2019	Consciousness
Pavičić, M.; Waegell, M.; Megill, N.D.; Aravind, P.	Automated generation of Kochen-Specker sets	2019	Physics
Benson K., Jensen G.	Bacteria in blood from fibromyalgia patients include the Aquabacterium genus, producing metabolites with inflammatory properties in vitro. Results from a pilot study	2019	Biology
Wharton, K.B.; Argaman, N.	Bell's Theorem and Spacetime-Based Reformulations of Quantum Mechanics	2019	Physics
Levy, C.S.; Kornack, T.W.; Mercier, P.P.	Bell-Bloom Magnetometer Linearization by Intensity Modulation Cancellation	2019	Physics
Waegell, M.; Dressel, J.	Benchmarks of nonclassicality for qubit arrays	2019	Physics
Pearl, J.; Cavalcanti, E.	Classical causal models cannot faithfully explain Bell nonlocality or Kochen-Specker contextuality in arbitrary scenarios	2019	Physics
Carlesso, M.; Donadi, S.	Collapse models: main properties and the state of art of the experimental tests	2019	Physics

Back to Publications

PUBLICATIONS

QUANTUM CORRELATIONS AND QUANTUM NON-LOCALITY: A REVIEW AND A FEW NEW IDEAS

arXiv

Info

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YEAR
2019

FIELD OF SCIENCE
Physics

In this paper we make an extensive description of quantum non-locality, one of the most intriguing and fascinating facets of quantum mechanics. After a general presentation of several studies on this subject, we consider if quantum non-locality, and the friction it carries with special relativity, can eventually find a "solution" by considering higher dimensional spaces.
The article was published in: *arXiv preprint arXiv:1908.03114*.

Full article

This work was supported (in part) by the Fetzer Franklin Fund of the John E. Fetzer Memorial Trust.

Back to Publications

PUBLICATIONS

QUANTUM THEORY AND THE PLACE OF MIND IN THE CAUSAL ORDER OF THINGS

Quanta and Mind Springer. 163-171

Info

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YEAR
2019

FIELD OF SCIENCE
Consciousness, Physics

The received view in physicalist philosophy of mind assumes that causation can only take place at the physical domain and that the physical domain is causally closed. It is often thought that this leaves no room for mental states qua mental to have a causal influence upon the physical domain, leading to epiphenomenalism and the problem of mental causation. However, in recent philosophy of causation there has been growing interest in a line of thought that can be called causal antifundamentalism: causal notions cannot play a role in physics, because the fundamental laws of physics are radically different from causal laws.

Causal anti-fundamentalism seems to challenge the received view in physicalist philosophy of mind and thus raises the possibility of there being genuine mental causation after all. This paper argues that while causal anti-fundamentalism provides a possible route to mental causation, we have reasons to think that it is incorrect. Does this mean that we have to accept the received view and give up the hope of genuine mental causation? I will suggest that the ontological interpretation of quantum theory provides us both with a view about the nature of causality in fundamental physics, as well as a view how genuine mental causation can be compatible with our fundamental (quantum) physical ontology.

The article was published in: Quanta and Mind Springer. 163-171.

Full article

This work was supported (in part) by the Fetzer Franklin Fund of the John E. Fetzer Memorial Trust.

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PUBLICATIONS

QUANTUM TRAJECTORIES: DIRAC, MOYAL AND BOHM

arXiv

Info

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YEAR
2016

FIELD OF SCIENCE
Physics

We recall Dirac's early proposals to develop a description of quan- tum phenomena in terms of a non-commutative algebra in which he suggested a way to construct what he called 'quantum trajectories'. Generalising these ideas, we show how they are related to weak val- ues and explore their use in the experimental construction of quantum trajectories.

We discuss covering spaces which play an essential role in accounting for the 'wave' properties of quantum particles. We briefly point out how new mathematical techniques take us beyond Hilbert space and into a deeper structure which connects with the algebras originally introduced by Born, Heisenberg and Jordan. This enables us to bring out the geometric aspects of quantum phenomena.

The article was published in: arXiv, 23th October 2016

Full article

This work was supported (in part) by the Fetzer Franklin Fund of the John E. Fetzer Memorial Trust.

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PUBLICATIONS

QUANTUM VIOLATION OF THE PIGEONHOLE PRINCIPLE AND THE NATURE OF QUANTUM CORRELATIONS

Proceedings of the National Academy of Sciences

The pigeonhole principle: "If you put three pigeons in two pigeonholes, at least two of the pigeons end up in the same hole," is an obvious yet fundamental principle of nature as it captures the very essence of counting. Here however we show that in quantum mechanics this is not true! We find instances when three quantum particles are put in two boxes, yet no two particles are in the same box.

Furthermore, we show that the above "quantum pigeonhole principle" is only one of a host of related quantum effects, and points to a very interesting structure of quantum mechanics that was hitherto unnoticed. Our results shed new light on the very notions of separability and correlations in quantum mechanics and on the nature of interactions. It also presents a new role for entanglement, complementary to the usual one. Finally, interferometric experiments that illustrate our effects are proposed.

The article was pulished in: Proceedings of the National Academy of Sciences: 201522411.

Full article

This work was supported (in part) by the Fetzer Franklin Fund of the John E. Fetzer Memorial Trust.

Info

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H. H. Wills Physics Laboratory, University of Bristol, UK

YEAR
2016

FIELD OF SCIENCE
Physics

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PUBLICATIONS

QUANTUM-LIKE BEHAVIOR OF CLASSICAL SYSTEMS

'International Symposium on Quantum Interaction'

Info

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YEAR
2012

FIELD OF SCIENCE
Physics

Bohmian mechanics is an example for a classical theory with a (Newtonian) ontology which reproduces all features of quantum mechanics. It is often used as a “classical” formulation of quantum mechanics, but in this article we invert the argument: Bohmian mechanics proves that there are classical systems which can show a quantum-like behavior; in particular, such models are able to explain non-classical probabilities.

We analyze the general structure of Bohmian-type models and argue, that neural processes related to the correlates of mental states are likely to follow a dynamics which is similar to this class of models. Therefore, it may not be too surprising that cognitive phenomena under certain circumstances show a quantum-like behavior.

The article was published in: Springer: 196-206. Proceedings of: ‘International Symposium on Quantum Interaction’

Full article

This work was supported (in part) by the Fetzer Franklin Fund of the John E. Fetzer Memorial Trust.

Back to Publications

PUBLICATIONS

REJECTING A BAD OPTION FEELS LIKE CHOOSING A GOOD ONE

Journal of Personality and Social Psychology

Info

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YEAR
2017

FIELD OF SCIENCE
Consciousness

Across 4,151 participants, the authors demonstrate a novel framing effect, attribute matching, whereby matching a salient attribute of a decision frame with that of a decision's options facilitates decision-making. This attribute matching is shown to increase decision confidence and, ultimately, consensus estimates by increasing feelings of metacognitive ease. In Study 1, participants choosing the more attractive of two faces or rejecting the less attractive face reported greater confidence in and perceived consensus around their decision.

Using positive and negative words, Study 2 showed that the attribute's extremity moderates the size of the effect. Study 3 found decision ease mediates these changes in confidence and consensus estimates. Consistent with a misattribution account, when participants were warned about this external source of ease in Study 4, the effect disappeared. Study 5 extended attribute matching beyond valence to objective judgments. The authors conclude by discussing related psychological constructs as well as downstream consequences.

The article was published in: Journal of Personality and Social Psychology, Vol 113(5), Nov 2017, 659-670

Full article

This work was supported (in part) by the Fetzer Franklin Fund of the John E. Fetzer Memorial Trust.

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PUBLICATIONS

RELATIONAL CAUSALITY AND CLASSICAL PROBABILITY: GROUNDING QUANTUM PHENOMENOLOGY IN A SUPERCLASSICAL THEORY

IOP Publishing

By introducing the concepts of "superclassicality" and "relational causality", it is shown here that the velocity field emerging from an n-slit system can be calculated as an average classical velocity field with suitable weightings per channel. No deviation from classical probability theory is necessary in order to arrive at the resulting probability distributions.

In addition, we can directly show that when translating the thus obtained expression for said velocity field into a more familiar quantum language, one immediately derives the basic postulate of the deBroglie-Bohm theory, i.e. the guidance equation, and, as a corollary, the exact expression for the quantum mechanical probability density current. Some other direct consequences of this result will be discussed, such as an explanation of Born's rule and Sorkin's first and higher order sum rules, respectively.

The article was published in: 'Journal of Physics: Conference Series', IOP Publishing: 012006.

Full article

This work was supported (in part) by the Fetzer Franklin Fund of the John E. Fetzer Memorial Trust.

Info

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YEAR
2014

FIELD OF SCIENCE
Physics

Back to Publications

PUBLICATIONS

RESOLUTION OF 90 NM (Λ/5) IN AN OPTICAL TRANSMISSION MICROSCOPE WITH AN ANNULAR CONDENSER

Optics Lett. 31, 2855-2857

Resolution of 90 nm was achieved with a research microscope simply by replacing the standard bright-field condenser with a homebuilt illumination system with a cardioid annular condenser. Diffraction gratings with 100 nm width lines as well as less than 100 nm size features of different-shaped objects were clearly visible on a calibrated microscope test slide.

The resolution increase results from a known narrower diffraction pattern in coherent illumination for the annular aperture compared with the circular aperture. This explanation is supported by an excellent accord of calculated and measured diffraction patterns for a 50 nm radius disk.

The article was published in: Optics Letters, Nr. 31, 2855-2857.

Full article

This work was supported (in part) by the Fetzer Franklin Fund of the John E. Fetzer Memorial Trust.

Info

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YEAR
2006

FIELD OF SCIENCE
Physics

Back to Publications

PUBLICATIONS

RESPONSIBILITY WITHOUT FREEDOM? FOLK JUDGEMENTS ABOUT DELIBERATE ACTIONS

Frontiers in Psychology 10

Info

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YEAR
2019

FIELD OF SCIENCE
Consciousness

A long-standing position in philosophy, law, and theology is that a person can be held morally responsible for an action only if they had the freedom to choose and to act otherwise. Thus, many philosophers consider freedom to be a necessary condition for moral responsibility.

However, empirical findings suggest that this assumption might not be in line with common sense thinking. For example, in a recent study we used surveys to show that – counter to positions held by many philosophers – lay people consider actions to be free when they are spontaneous rather than being based on reasons. In contrast, responsibility is often considered to require that someone has thought about the alternative options. In this study we used an online survey to directly test the degree to which lay judgements of freedom and responsibility match.

Specifically, we tested whether manipulations of deliberation affect freedom and responsibility judgements in the same way. Furthermore, we also tested the dependency of these judgements on a person's belief that their decision had consequences for their personal life. We found that deliberation had an opposite effect on freedom and responsibility judgements. People were considered more free when they acted spontaneously, whereas they were considered more responsible when they deliberated about their actions. These results seem to suggest that deliberating about reasons is crucially important for the lay concept of responsibility, while for the lay notion of freedom it is perceived to be detrimental.

One way of interpreting our findings for the interdisciplinary debate on free will and responsibility could be to suggest that lay beliefs match the philosophical position of semi-compatibilism. Semi-compatibilists insist that the metaphysical debate on the nature of free will can be separated from the debate on conditions of responsible agency. According to our findings the beliefs of lay people are in line with views held by semi-compatibilists, even though we did not test whether they endorse that position explicitly.

The article was published in: Frontiers in Psychology 10: 1133.

Full article

This work was supported (in part) by the Fetzer Franklin Fund of the John E. Fetzer Memorial Trust.

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PUBLICATIONS

REVEALING THE EMERGENCE OF CLASSICALITY USING NITROGEN-VACANCY CENTERS

The European Physical Journal Special Topics 227

In an EPR setup, simultaneous measurement of two non- commuting observables is considered at station A and, possibly after a time delay, at station B. At each station one apparatus measures the z-component of a spin, while a second one measures the x-component of the same spin simultaneously. The dynamics of the measurements is solved explicitly.

It is shown that no violations of Bell inequalities occur in Bell-like correlation experiments, and that, in fact, experiments of this type are subject to even stronger constraints. This is caused by the mutual influence of the two apparatuses coupled to the same spin, an effect which occurs at both stations.

The article was published in: The European Physical Journal Special Topics 227(15-16): 2209-2219.

Full article

This work was supported (in part) by the Fetzer Franklin Fund of the John E. Fetzer Memorial Trust.

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YEAR
2019

FIELD OF SCIENCE
Physics

Back to Publications

PUBLICATIONS

RUSHING TOWARDS VIRTUE: TIME PRESSURE INCREASES SOCIALLY DESIRABLE RESPONDING

PsyArXiv

The oldest method in psychology of trying to gain access to one part of a divided mind is to instruct participants to answer quickly. Here we propose an alternative account for this procedure, namely, that it makes people give the socially desirable response. We randomly assigned 1,500 Americans to answer a social desirability scale either quickly or slowly. We use an intention-to-treat analysis to test the effects quick vs. slow responding on social desirability.

We show quick responding causes an increase in social desirability. We propose that a number of findings using the fast/slow responding manipulation can be partially or entirely explained by participants' giving the socially desirable response. Future investigations using the time pressure manipulation should account for social desirability to ensure the results are not entirely driven by this mechanism.

The article was published in: PsyArXiv. August 14.

Full article

This work was supported (in part) by the Fetzer Franklin Fund of the John E. Fetzer Memorial Trust.

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YEAR
2018

FIELD OF SCIENCE
Consciousness

Back to Publications

PUBLICATIONS

SCIENTISTS' REPUTATIONS ARE BASED ON GETTING IT RIGHT, NOT BEING RIGHT

PLoS Biology

Replication is vital for increasing precision and accuracy of scientific claims. However, when replications "succeed" or "fail," they could have reputational consequences for the claim's originators. Surveys of United States adults (*N* = 4,786), undergraduates (*N* = 428), and researchers (*N* = 313) showed that reputational assessments of scientists were based more on how they pursue knowledge and respond to replication evidence, not whether the initial results were true.

When comparing one scientist that produced boring but certain results with another that produced exciting but uncertain results, opinion favored the former despite researchers' belief in more rewards for the latter. Considering idealized views of scientific practices offers an opportunity to address incentives to reward both innovation and verification.

The article was published in: PLoS Biol. 14(5): e1002460.

Full article

This work was supported (in part) by the Fetzer Franklin Fund of the John E. Fetzer Memorial Trust.

Info

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YEAR
2016

FIELD OF SCIENCE
Physics

Back to Publications

PUBLICATIONS

SIMULTANEOUS MEASUREMENT OF NON-COMMUTING OBSERVABLES IN ENTANGLED SYSTEMS

The European Physical Journal Special

In an EPR setup, simultaneous measurement of two non- commuting observables is considered at station A and, possibly after a time delay, at station B. At each station one apparatus measures the z-component of a spin, while a second one measures the x-component of the same spin simultaneously. The dynamics of the measurements is solved explicitly. It is shown that no violations of Bell inequalities occur in Bell-like correlation experiments, and that, in fact, experiments of this type are subject to even stronger constraints. This is caused by the mutual influence of the two apparatuses coupled to the same spin, an effect which occurs at both stations.

Info

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YEAR
2019

FIELD OF SCIENCE
Physics

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PUBLICATIONS

SPATIOTEMPORAL IMAGING OF COMPLEXITY

Frontiers in Computational Neuroscience 6

What are the functional neuroimaging measurements required for more fully characterizing the events and locations of neocortical activity? A prime assumption has been that modulation of cortical activity will inevitably be reflected in changes in energy utilization (for the most part) changes of glucose and oxygen consumption. Are such a measures complete and sufficient? More direct measures of cortical electrophysiological activity show event or task-related modulation of amplitude or band-limited oscillatory power.

Using magnetoencephalography (MEG), these measures have been shown to correlate well with energy utilization sensitive BOLD fMRI. In this paper, we explore the existence of state changes in electrophysiological cortical activity that can occur independently of changes in averaged amplitude, source power or indices of metabolic rates. In addition, we demonstrate that such state changes can be described by applying a new measure of complexity, rank vector entropy (RVE), to source waveform estimates from beamformer-processed MEG. RVE is a non-parametric symbolic dynamic informational entropy measure that accommodates the wide dynamic range of measured brain signals while resolving its temporal variations.

By representing the measurements by their rank values, RVE overcomes the problem of defining embedding space partitions without resorting to signal compression. This renders RVE-independent of absolute signal amplitude. In addition, this approach is robust, being relatively free of tunable parameters. We present examples of task-free and task-dependent MEG demonstrating that RVE provides new information by uncovering hidden dynamical structure in the apparent turbulent (or chaotic) dynamics of spontaneous cortical activity.

Published in: Frontiers in Computational Neuroscience 6(101).

Full article

This work was supported (in part) by the Fetzer Franklin Fund of the John E. Fetzer Memorial Trust.

Info

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Department of Psychiatry, University California, San Diego, CA, USA

YEAR
2013

FIELD OF SCIENCE
Biology

Back to Publications

PUBLICATIONS

SPOOKY WORK AT A DISTANCE: AN INTERACTION-FREE QUANTUM MEASUREMENT-DRIVEN ENGINE

arXiv

Info

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YEAR
2019

FIELD OF SCIENCE
Physics

Recent progress in the science of quantum measurement has focused on the energy associated with the wavefunction collapse process. Energy may be stochastically transferred from the measurement probe to the system being measured, such that a highly efficient quantum measurement powered engine can be realized with cyclic feedback. Here we show that this work extraction can be done in a nonlocal way using interaction free measurements, despite a local interaction Hamiltonian. By putting an Elitzur-Vaidman bomb in one arm of a tuned Mach-Zehnder interferometer, the detection of a photon in the dark port of the interferometer indicates the bombs presence without blowing it up.
Treating the bomb quantum mechanically, the bombs ground state exists in superposition of inside and outside the interferometer arm. If the optical dark port fires, the bombs wavefunc- tion must collapse inside the interferometer arm, which raises the bombs energy. The energy can then be extracted in the engine cycle. Crucially, the wavefunction collapse of the bomb inside the interferometer arm indicates the photon could not have taken the path the bomb was localized in, otherwise it would have absorbed the photon and exploded.
Therefore, the work done on the bomb by the photon is seemingly nonlocal. We complement this discussion by calculating the anomalous measurable energy gain when postselecting realizations where the dark port fires. Regardless of interpretation, this interaction free quantum measurement engine is able to lift the most sensitive bomb without setting it off.
The article was published in: *arXiv preprint arXiv:1904.09289*

Full article

This work was supported (in part) by the Fetzer Franklin Fund of the John E. Fetzer Memorial Trust.

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PUBLICATIONS

STOCHASTIC GRAVITY AND ONTOLOGICAL QUANTUM MECHANICS

Preprints 2018

Info

AUTHORS
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INSTITUTION
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YEAR
2018

FIELD OF SCIENCE
Physics

Some physicists surmise that gravity lies outside of quantum mechanics. Thus theories like the standard semiclassical theory of quantum to gravity coupling (that of Rosenfeld and Møller) are possible real models of interaction, rather than a mere approximation of a theory of quantum gravity. Unfortunately, semiclassical gravity creates inconsistencies such as superluminal communication. Alternatives by authors such as Diósi, Martin, Penrose, and Wang often use the term 'stochastic' to set themselves apart from the standard semiclassical theory.

These theories couple to fluctuations caused by for instance continuous spontaneous localization, hence the term 'stochastic'. This paper looks at stochastic gravity in the framework of a class of emergent or ontological quantum theories, such as those by Bohm, Cetto, and de Broglie. It is found that much or all of the trouble in connecting gravity with a microscopic system falls away, as Einstein's general relativity is free to react directly with the microscopic beables.

The resulting continuous gravitational wave radiation by atomic and nuclear systems does not, in contrast to Einstein's speculation, cause catastrophic problems. The small amount of energy exchanged by gravitational waves may have measurable experimental consequences. A very recent experiment by Vinante et al. performed on a small cantilever at mK temperatures shows a surprising non-thermal noise component, the magnitude of which is consistent with the stochastic gravity coupling explored here.

The article was published in: Preprints 2018, 2018040345.

Full article

This work was supported (in part) by the Fetzer Franklin Fund of the John E. Fetzer Memorial Trust.

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PUBLICATIONS

STRENGTHENING WEAK MEASUREMENTS OF QUBIT OUT-OF-TIME-ORDER CORRELATORS

Physical Review A 98(1)

For systems of controllable qubits, we provide a method for experimentally obtaining a use- ful class of multitime correlators using sequential generalized measurements of arbitrary strength. Specifically, if a correlator can be expressed as an average of nested (anti)commutators of operators that square to the identity, then that correlator can be determined exactly from the average of a measurement sequence.

As a relevant example, we provide quantum circuits for measuring multi- qubit out-of-time-order correlators using optimized control-Z or ZX -90 two-qubit gates common in superconducting transmon implementations.

The article was published in: Physical Review A 98(1): 012132.

Full article

This work was supported (in part) by the Fetzer Franklin Fund of the John E. Fetzer Memorial Trust.

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YEAR
2018

FIELD OF SCIENCE
Physics

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PUBLICATIONS

STRUCTURE PROCESS, WEAK VALUES AND LOCAL MOMENTUM

Journal of Physics: Conference Series, Volume 701

Info

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YEAR
2016

FIELD OF SCIENCE
Physics

We understand emergent quantum mechanics in the sense that quantum mechanics describes processes of physical emergence relating an assumed sub-quantum physics to macroscopic boundary conditions. The latter can be shown to entail top-down causation, in addition to usual bottom-up scenarios. With this example it is demonstrated that definitions of "realism" in the literature are simply too restrictive. A prevailing manner to define realism in quantum mechanics is in terms of pre-determination independent of the measurement.

With our counter-example, which actually is ubiquitous in emergent, or self-organizing, systems, we argue for realism without pre-determination. We refer to earlier results of our group showing how the guiding equation of the de Broglie–Bohm interpretation can be derived from a theory with classical ingredients only. Essentially, this corresponds to a "quantum mechanics without wave functions" in ordinary 3-space, albeit with nonlocal correlations.

The article was published in: Journal of Physics: Conference Series, Volume 701

Full article

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PUBLICATIONS

STUDY OF VISUAL STIMULUS WAVEFORMS VIA FORCED VAN DER POL OSCILLATOR MODEL FOR SSVEP-BASED BRAIN-COMPUTER INTERFACES

2013 International Conference on Communications, Circuits and Systems (ICCCAS)

Visual stimulus design is a central problem for practical brain-computer interfaces (BCIs) based on steady state visually evoked potentials (SSVEPs). In this study, we compare the performances of three differing stimulus waveforms: sine wave, square wave of 50% duty cycle, and the output of the autonomous van der Pol oscillator. The human brain SSVEP is modeled with a forced van der Pol oscillator in which these three driving waveforms are individually applied. In doing so, we use binary search to yield equation parameters that predictably generates frequency maxima in the desired ratio.

We compare the minimum amplitude required for each stimulus to activate a corresponding local maximum within the relevant frequency band. We then compute and graph a suitably defined signal-to-noise ratio (SNR) in relation to stimulus frequency for the three waveforms in order to ascertain their relative rates of synchronization. This theoretical exploration has its aim to provide a guideline to the development of an optimal visual stimulus pattern for use in real life SSVEP-based BCI applications.

The article was published in: 2013 International Conference on Communications, Circuits and Systems (ICCCAS). 2: 475-479.

Full article

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YEAR
2013

FIELD OF SCIENCE
Biology

Back to Publications

PUBLICATIONS

THE BIOINFORMATIC BASIS OF PAN-ASIANISM

East Asian Science, Technology and Society (2013)

Info

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YEAR
2013

FIELD OF SCIENCE
Biology

The socially calculated Asian body is an abstract discursive space bridging early twentieth- and twenty-first-century Pan-Asianism across multiple scientific understandings of race and ethnicity. In the early twentieth century, the pan-Asian body was a static, statistical taxonomy of precisely measured blood and body parts. As an administrative tool of empire and nation building, the quantitatively defined Asian was plotted along Cartesian coordinates of racial purity. By the twenty-first century, new computational technologies flexibly supported both national and transcendent pan-Asian ethnic identities by constructing regional populations as dynamic probabilistic clusters over time.

This paper focuses on how the Pan-Asian SNP Consortium (PASNP) of the Human Genome Organisation (HUGO), the first inter-Asian genomics collaboration, embodied a revival of Pan-Asianism in both the members' collaborative network and scientific research. As a network of scientists, the PASNP members heralded the spirit of regional cooperation to bring about the rise of a pan-Asian research area in science. Through their research, the members reflexively calculated a new narrative of the shared ethnic origin and genetic unity of the region.

Biochip data, probabilistic clustering algorithms, and computer simulations in the hands of Asian scientists calculated that the region was most likely populated as a single wave of historical migration. This overturned the dominant theory supported by Western-led international projects that divided Asian populations. The PASNP thus mapped the metageography of Pan-Asianism through big data computation.

The article was published in: East Asian Science, Technology and Society (2013) 7 (2): 283-309.

Full article

This work was supported (in part) by the Fetzer Franklin Fund of the John E. Fetzer Memorial Trust.

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PUBLICATIONS

THE BLOOD AS A DIAGNOSTICS TOOL IN CHRONIC ILLNESS WITH OBSCURE MICROBIAL INVOLVEMENT: A CRITICAL REVIEW

IJCAM. 2019;12(6):232–239

Advanced research into human health and effects of the bacteria around us and inside us is reaching new and unprecedented levels of understanding. However, the information is not reaching the general integrated practitioner fast enough, nor do the findings provide clear feedback to translational medicine for optimal treatment of chronically ill patients. This review paper intends to provide an overview of today's knowledge, clarify historical observations, and offer some initial levels of scientific grounding for health practitioners.

As the studies of biology and medicine grew from infancy through the 19th century, leading scientists identified bacteria as causative agents in many diseases. These findings steered medical microbiology towards the germ theory, the "one-microbe, one-disease" concept. Today, modern microbiology has rocketed beyond such simplified concepts, and shown the capacity of microbial life forms to exchange genetic material, form stealthy biofilm, and live under extreme conditions in forms that are not recognizable as specific species or classical morphological forms.

The scientific understanding and medical use of the human blood for diagnosis and treatment decisions has wavered back and forth over the past 150 years. Early microscopists found morphological evidence for apparent microbial-like forms and associated these with health status and illness. This was followed by a more rigid medical microbiology textbook dogma, based on the concept that the human blood is a sterile environment, and any microbial form observed as a sign of infection, i.e. an invasion by an unwanted microbial form, is specifically linked such that one microbial species will initiate one highly specific pattern of health breakdown.

During the last 20 years, the earlier simplified dogmas have been supplanted. Very recently, it has been shown beyond doubt that broad and complex microbial communities ('microbiomes') exist not only in our gut and on our skin, but also in our blood circulation, in cells, tissue, and inside tumors. The intricate interplay between a person's immune status and health provides a complex backdrop for how the microbial world affects our health and wellbeing.

Full article

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2019

FIELD OF SCIENCE
Biology

Back to Publications

PUBLICATIONS

THE CATEGORY SIZE BIAS: A MERE MISUNDERSTANDING

Judgment and Decision Making, Vol. 13, No. 2

Info

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YEAR
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FIELD OF SCIENCE
Consciousness

Redundant or excessive information can sometimes lead people to lean on it unnecessarily. Certain experimental designs can sometimes bias results in the researcher's favor. And, sometimes, interesting effects are too small to be studied, practically, or are simply zero. We believe a confluence of these factors led to a recent paper (Isaac & Brough, 2014, JCR).

This initial paper proposed a new means by which probability judgments can be led astray: the category size bias, by which an individual event coming from a large category is judged more likely to occur than an event coming from a small one. Our work shows that this effect may be due to instructional and mechanical confounds, rather than interesting psychology.

We present eleven studies with over ten times the sample size of the original in support of our conclusion: We replicate three of the five original studies and reduce or eliminate the effect by resolving these methodological issues, even significantly reversing the bias in one case (Study 6). Studies 7-8c suggest the remaining two studies are false positives. We conclude with a discussion of the subtleties of instruction wording, the difficulties of correcting the record, and the importance of replication and open science.

The article was published in: Judgment and Decision Making, Vol. 13, No. 2, March 2018, pp. 170-184

Full article

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PUBLICATIONS

THE CIRCULATION OF SERICULTURE KNOWLEDGE THROUGH TEMPLE NETWORKS AND COGNITIVE POETICS IN 18TH CENTURY ZHEJIANG

Springer

Info

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YEAR
2014

FIELD OF SCIENCE
Foundations

The circulation of sericulture technology and religion were shaped by social historical factors as well as cognitive processes. The spread of silkworm temples in Zhejiang reflected a complex dynamic between imperial rule and local popular religion related to crafts. Temples were the nodes of social networks along which information flowed in the form of ritual and song.

The article was published in: Motion and Knowledge in the Changing Early Modern World Springer. 115-137.

Full article

This work was supported (in part) by the Fetzer Franklin Fund of the John E. Fetzer Memorial Trust.

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PUBLICATIONS

THE CONCEPT OF COMPLEMENTARITY AND ITS ROLE IN QUANTUM ENTANGLEMENT AND GENERALIZED ENTANGLEMENT

Axiomathes 23(3): 443-459.

Info

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YEAR
2012

FIELD OF SCIENCE
Physics

The term complementarity plays a central role in quantum physics, not least in various approaches to defining entanglement and the conditions for its occurrence. It has, however, been used in a variety of ways by different authors, denoting different concepts and relationships. Here we describe and clarify some of them and analyze the role they play with respect to the phenomenon of entanglement.

Based on these considerations we discuss the recently proposed system-theoretical generalization of the concepts entanglement and complementarity (Atmanspacher et al. in Found Phys 32(3):379–406, 2002; von Lucadou et al. in J Conscious Stud 14(4):50–74, 2007; Filk and Römer in Axiomathes 21(2):211–220, 2011; Walach and Von Stillfried in Axiomathes 21(2): 185–209, 2011). We hope that a clarification regarding the specific meaning of these terms can be useful to the growing engagement with this interesting hypothesis and its critical investigation.

The article was published in: Axiomathes 23(3): 443-459.

Full article

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YEAR
2018

FIELD OF SCIENCE
Physics

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PUBLICATIONS

THE DIRAC-BOHM PICTURE

arXiv:1809

We examine Dirac's early algebraic approach which introduces the standard ket and show that it emerges more clearly from a unitary transformation of the operators based on the action. This establishes a new picture that is unitarily equivalent to both the Schr¨odinger and Heisenberg pictures. We will call this the Dirac-Bohm picture for the reasons we discuss in the paper.
This picture forms the basis of the Feynman path theory and allows us to show that the so-called 'Bohm trajectories' are averages of an ensemble of Feynman paths.
The article was published in: arXiv preprint arXiv:1809.06072.

Full article

This work was supported (in part) by the Fetzer Franklin Fund of the John E. Fetzer Memorial Trust.

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PUBLICATIONS

THE NON-SIGNALLING THEOREM IN GENERALIZATIONS OF BELL'S THEOREM

Journal of Physics: Conference Series 504

Info

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YEAR
2014

FIELD OF SCIENCE
Physics

Does "epistemic non-signalling" ensure the peaceful coexistence of special relativity and quantum nonlocality? The possibility of an affirmative answer is of great importance to deterministic approaches to quantum mechanics given recent developments towards generalizations of Bell's theorem. By generalizations of Bell's theorem we here mean efforts that seek to demonstrate the impossibility of any deterministic theories to obey the predictions of Bell's theorem, including not only local hidden-variables theories (LHVTs) but, critically, of nonlocal hidden-variables theories (NHVTs) also, such as de Broglie-Bohm theory.
Naturally, in light of the well-established experimental findings from quantum physics, whether or not a deterministic approach to quantum mechanics, including an emergent quantum mechanics, is logically possible, depends on compatibility with the predictions of Bell's theorem.
The article was published in: Journal of Physics: Conference Series 504: 012001.

Full article

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PUBLICATIONS

THE QUANTUM SWEEPER EFFECT

Journal of Physics: Conference Series 626

We show that during stochastic beam attenuation in double slit experiments, there appear unex- pected new effects for transmission factors below a <10−4, which can eventually be observed with the aid of weak measurement techniques. These are denoted as quantum sweeper effects, which are characterized by the bunching together of low counting rate particles within very narrow spatial domains.

We employ a "superclassical" modeling procedure which we have previously shown to produce predictions identical with those of standard quantum theory. Thus it is demonstrated that in reaching down to ever weaker channel intensities, the nonlinear nature of the probability den- sity currents becomes ever more important. We finally show that the resulting unexpected effects nevertheless implicitly also exist in standard quantum mechanics.

The article was published in: Journal of Physics: Conference Series 626: 012017.

Full article

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YEAR
2015

FIELD OF SCIENCE
Physics

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PUBLICATIONS

THE SUPER-INDETERMINISM IN ORTHODOX QUANTUM MECHANICS DOES NOT IMPLICATE THE REALITY OF EXPERIMENTER FREE WILL

Journal of Physics: Conference Series

Info

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YEAR
2016

FIELD OF SCIENCE
Physics

The concept of 'super-indeterminism' captures the notion that the free choice assumption of orthodox quantum mechanics necessitates only the following requirement: an agent's free-choice performance in the selection of measurement settings must not represent an exception to the rule of irreducible quantum indeterminism in the physical universe (i.e, "universal indeterminism"). Any additional metaphysical speculation, such as to whether quantum indeterminism, i.e., intrinsic randomness, implicates the reality of experimenter "freedom", "free will", or "free choice", is redundant in relation to the predictive success of orthodox quantum mechanics.

Accordingly, super-indeterminism views as redundant also, from a technical standpoint, whether an affirmative or a negative answer is claimed in reference to universal indeterminism as a necessary precondition for experimenter freedom. Super-indeterminism accounts, for example, for the circular reasoning which is implicit in the free will theorem by Conway and Kochen [1, 2]. The concept of super- indeterminism is of great assistance in clarifying the often misunderstood meaning of the concept of "free variables" as used by John Bell [3].

The present work argues that Bell sought an operational, effective free will theorem, one based upon the notion of "determinism without predetermination", i.e., one wherein "free variables" represent universally uncomputable variables. In conclusion, the standard interpretation of quantum theory does not answer, and does not need to answer in order to ensure the predictive success of orthodox theory, the question of whether either incompatibilism or compatibilism is valid in relation to free-will metaphysics and to the free-will phenomenology of experimenter agents in quantum mechanics.

The article was published in: Journal of Physics: Conference Series, 701(1): 012005.

Full article

This work was supported (in part) by the Fetzer Franklin Fund of the John E. Fetzer Memorial Trust.

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PUBLICATIONS

THE SYNTHESIS OF RELIGIOUS AND MEDICAL HEALING RITUALS IN THE SONG

Asian Religions, Technology and Science Routledge

Info

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YEAR
2015

FIELD OF SCIENCE
Consciousness, Foundations

The Northern Song's (960-1127) attempts to standardize medicine and popular religion were part of an integrated whole, especially under the reign of Emperor Huizong 徽宗 (r. 1100-1125) in the twelfth century. The government attempted to establish networks of local medical schools and Divine Empyrean temples that followed state orthodoxy.

The state also sponsored the collation of medical texts into compendia such as the General Record of Sagely Benefaction (Sheng ji zonglu 聖濟總錄) and religious texts into the Longevity Daoist Canon (Wan shou dao zang 萬壽道藏).

The medical system was to be staffed by state doctors who passed a newly established medical exam that mirrored the civil service test. Huizong also co-opted many leaders of religious movements by grantingd them titles in the imperial court. These sweeping attempts to bring religion and medicine under imperial order were reflected in the synthesis of ritual healing techniques and medical theories.

Imperial Medical Academy physicians in the twelfth century sought to incorporate exorcism and healing rituals associated with contemporary religious movements and explain them using theories of the circulation of qi and the various somatic manifestations of possession. One way they did this was by explaining the expulsion and protection against ghosts, otherwise known as interdiction or jin禁, as a matter of praying about the cause of illness zhuyou 祝由 to move and transform qi in the body.

The article was published in. Asian Religions, Technology and Science Routledge. 134-148.

Full article

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PUBLICATIONS

THE TURBULENT HUMAN BRAIN: AN MHD APPROACH TO THE MEG

Chapter of "Criticality in Neural Systems"

Info

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YEAR
2014

FIELD OF SCIENCE
Biology, Physics

The article is a chapter of the book "Criticality in Neural Systems": 127-152.

The chapter contains sections titled:

- Introduction
- Autonomous, Intermittent, Hierarchical Motions, from Brain Proteins Fluctuations to
- Emergent Magnetic Fields
- Magnetic Field Induction and Turbulence; Its Maintenance, Decay, and Modulation
- Localizing a Time-Varying Entropy Measure of Turbulence, Rank Vector Entropy (RVE)
- [35, 107], Using a Linearly Constrained Minimum Variance (LCMV) Beamformer Such
- as Synthetic Aperture Magnetometry (SAM) [25, 34], Yields State and Function-
- Related Localized Increases and Decreases in the RVE Estimate
- Potential Implications of the MHD Approach to MEG Magnetic Fields for
- Understanding the Mechanisms of Action and Clinical Applications of the Family of
- TMS (Transcranial Magnetic Stimulation) Human Brain Therapies

Full article

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PUBLICATIONS

THE WEAK REALITY THAT MAKES QUANTUM PHENOMENA MORE NATURAL: NOVEL INSIGHTS AND EXPERIMENTS

Entropy 20(11)

While quantum reality can be probed through measurements, the Two-State-Vector formalism (TSVF) reveals a subtler reality prevailing between measurements. Under special pre- and post- selections, odd physical values emerge. This unusual picture calls for a deeper study. Instead of the common, wave-based picture of quantum mechanics, we suggest a new, particle-based perspective: Each particle possesses a definite location throughout its evolution, while some of its physical variables (characterized by deterministic operators, some of which obey nonlocal equations of motion) are carried by "mirage particles" accounting for its unique behavior.

Within the time-interval between pre- and post-selection, the particle gives rise to a horde of such mirage particles, of which some can be negative. What appears to be "no-particle," known to give rise to Interaction-Free Measurement, is in fact a self-canceling pair of positive and negative mirage particles, which can be momentarily split and cancel out again. Feasible experiments can give empirical evidence for these fleeting phenomena. In this respect, the Heisenberg ontology is shown to be conceptually advantageous compared to the Schrödinger picture. We review several recent advances, discuss their foundational significance and point out possible directions for future research.

The article was published in: *Entropy* 20(11): 854.

Full article

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YEAR
2018

FIELD OF SCIENCE
Physics

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PUBLICATIONS

THEORETICAL DESCRIPTION AND EXPERIMENTAL SIMULATION OF QUANTUM ENTANGLEMENT NEAR OPEN TIME-LIKE CURVES VIA PSEUDO-DENSITY OPERATORS

Nature communications 10(1)

Closed timelike curves are striking predictions of general relativity allowing for time-travel. They are afflicted by notorious causality issues (e.g. grandfather's paradox). Quantum models where a qubit travels back in time solve these problems, at the cost of violating quantum theory's linearity—leading e.g. to universal quantum cloning.

Interestingly, linearity is violated even by open timelike curves (OTCs), where the qubit does not interact with its past copy, but is initially entangled with another qubit. Non-linear dynamics is needed to avoid violating entanglement monogamy. Here we propose an alternative approach to OTCs, allowing for monogamy violations. Specifically, we describe the qubit in the OTC via a pseudo-density operator—a unified descriptor of both temporal and spatial correlations.

We also simulate the monogamy violation with polarization-entangled photons, providing a pseudo-density operator quantum tomography. Remarkably, our proposal applies to any space-time correlations violating entanglement monogamy, such as those arising in black holes.

The article was published in: *Nature communications* 10(1): 182.

Full article

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YEAR
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FIELD OF SCIENCE
Physics

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PUBLICATIONS

TIGHT BELL INEQUALITIES AND NONLOCALITY IN WEAK MEASUREMENT

APS Meeting Abstracts

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YEAR
2017

FIELD OF SCIENCE
Physics

A general class of Bell inequalities is derived based on strict adherence to probabilistic entanglement correlations observed in nature. This derivation gives significantly tighter bounds on local hidden variable theories for the well-known Clauser-Horne-Shimony-Holt (CHSH) inequality, and also leads to new proofs of the Greenberger-Horne-Zeilinger (GHZ) theorem.

This method is applied to weak measurements and reveals nonlocal correlations between the weak value and the post-selection, which rules out various classical models of weak measurement. Implications of these results are discussed.

The article was published in: Proceedings of: 'APS Meeting Abstracts'.

Full article

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PUBLICATIONS

TRIPLY POSITIVE MATRICES AND QUANTUM MEASUREMENTS MOTIVATED BY QBISM

arXiv

Info

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YEAR
2018

FIELD OF SCIENCE
Physics

We study a class of quantum measurements that furnish probabilistic representations of finite- dimensional quantum theory. The Gram matrices associated with these Minimal Informationally Com- plete quantum measurements (MICs) exhibit a rich structure. They are "positive" matrices in three different senses, and conditions expressed in terms of them have shown that the Symmetric Informa- tionally Complete measurements (SICs) are in some ways optimal among MICs.

Here, we explore MICs more widely than before, comparing and contrasting SICs with other classes of MICs, and using Gram matrices to begin the process of mapping the territory of all MICs. Moreover, the Gram matrices of MICs turn out to be key tools for relating the probabilistic representations of quantum theory furnished by MICs to quasi-probabilistic representations, like Wigner functions, which have proven relevant for quantum computation. Finally, we pose a number of conjectures, leaving them open for future work.

The article was pulished in: arXiv preprint arXiv:1812.08762.

Full article

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YEAR
2014

FIELD OF SCIENCE
Consciousness, Foundations

Back to Publications

PUBLICATIONS

TURNING THE LENS OF SCIENCE ON ITSELF

Perspectives on Psychological Science 9(5)

This issue of *Perspectives on Psychological Science* reports an unprecedented replication effort entailing numerous independent laboratories conducting two versions of the verbal overshadowing paradigm (Schooler & Engstler-Schooler, 1990) using different timing intervals.

The results (Alogna et al., 2014, this issue) provide unequivocal support for the existence of verbal overshadowing—the finding that describing a previously seen face can impair its subsequent recognition—while simultaneously revealing a number of factors that may have contributed to challenges in replicating verbal overshadowing in the past.

In this commentary, I review my participation in this process and consider the implications of the results of this replication effort for verbal overshadowing, the decline effect, and the general goal of metascience: turning the lens of science onto itself.

The article was published in: Perspectives on Psychological Science 9(5): 579-584.

Full article

This work was supported (in part) by the Fetzer Franklin Fund of the John E. Fetzer Memorial Trust.

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PUBLICATIONS

ULTRA-SLOW FREQUENCY BANDS REFLECTING POTENTIAL COHERENCE BETWEEN NEOCORTICAL BRAIN REGIONS

Neuroscience 289

Info

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YEAR
2015

FIELD OF SCIENCE
Physics

Recent studies of electromagnetic ultra-slow waves (≤ 0.1 Hz) have suggested that they play a role in the integration of otherwise disassociated brain regions supporting vital functions (Picchioni, Horovitz et al, 2011; Ackermann and Borbeley, 1997; Le Bon, Neu, Berquin et al, 2012; Knyazev, 2012). We emphasize this spectral domain in probing sensor coherence issues raised by these studies using Hilbert phase coherences in the human MEG.

In addition, we ask: will temporal-spatial phase coherence in regional brain oscillations obtained from the ultraslow spectral bands of multi-channel magnetoencephalograms (MEG) differentiate resting, "task free" MEG records of normal control and schizophrenic subjects. The goal of the study is a comparison of the relative persistence of intra-regional phase locking values, PLV, among ten, region-defined, sensors in examined in the resting multichannel, MEG records as a function of spectral frequency bands and diagnostic category.

The following comparison of Hilbert-transform-engendered relative phases of each designated spectral band was made using their pair-wise phase locking values, PLV. This indicated the proportion of shared cycle time in which the phase relations between the index location and reference leads were maintained. Leave one out, bootstrapping of the PLVs via a support vector machine, SVM, classified clinical status with 97.3% accuracy.

It was generally the case that spectral bands ≤ 1.0 Hz generated the highest values of the PLVs and discriminated best between control and patient populations. We conclude that PLV analysis of the oscillatory patterns of MEG recordings in the ultraslow frequency bands suggest their functional significance in intra-regional signal coherence and provide a higher rate of classification of patients and normal subjects then the other spectral domains examined.

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Full article

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PUBLICATIONS

USING EMPIRICAL MODE DECOMPOSITION WEIGHTING FUNCTIONALS AS TIME SERIES FILTERING COEFFICIENTS FOR PHYSIOLOGICAL RECORDINGS

Advances in Adaptive Data Analysis 4(01n02)

We present a method for enhancing signals possessing nonlinear and nonstationary characteristics, which we call weighting functional-empirical mode decomposition (WF-EMD). The filtering method is based upon the empirical mode decomposition (EMD) and utilizes an energy-based weighting scheme to recombine the decomposed modes into a single cleansed version of the signal.

The filter has been developed in such a way that no restrictive assumptions about the data are required. Furthermore, the temporal resolution of the data is left unaltered, as it would occur in many common data-smoothing methods. The design of this filter has been influenced by improving the calculation accuracy of dynamical measures, such as fractal dimensions and Lyapunov exponents, of neurodynamical recordings such as those obtained through electroencephalography (EEG) or magnetoencephalography (MEG).

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FIELD OF SCIENCE
Physics

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PUBLICATIONS

VACUUM LANDSCAPING: CAUSE OF NONLOCAL INFLUENCES WITHOUT SIGNALING

Entropy 20(6)

In the quest for an understanding of nonlocality with respect to an appropriate ontology, we propose a "cosmological solution". We assume that from the beginning of the universe each point in space has been the location of a scalar field representing a zero-point vacuum energy that nonlocally vibrates at a vast range of different frequencies across the whole universe. A quantum, then, is a nonequilibrium steady state in the form of a "bouncer" coupled resonantly to one of those (particle type dependent) frequencies, in remote analogy to the bouncing oil drops on an oscillating oil bath as in Couder's experiments.
A major difference to the latter analogy is given by the nonlocal nature of the vacuum oscillations. We show with the examples of double- and n-slit interference that the assumed nonlocality of the distribution functions alone suffices to derive the de˜Broglie--Bohm guiding equation for N particles with otherwise purely classical means. In our model, no influences from configuration space are required, as everything can be described in 3-space. Importantly, the setting up of an experimental arrangement limits and shapes the forward and osmotic contributions and is described as vacuum landscaping.
The article was published in: Entropy 20(6): 458.

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FIELD OF SCIENCE
Physics

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PUBLICATIONS

VARIATIONAL CONSISTENT HISTORIES AS A HYBRID ALGORITHM FOR QUANTUM FOUNDATIONS

Nature communications 10(1)

While quantum computers are predicted to have many commercial applications, less attention has been given to their potential for resolving foundational issues in quantum mechanics. Here we focus on quantum computers' utility for the Consistent Histories formalism, which has previously been employed to study quantum cosmology, quantum paradoxes, and the quantum-to-classical transition. We present a variational hybrid quantum-classical algorithm for finding consistent histories, which should revitalize interest in this formalism by allowing classically impossible calculations to be performed.

In our algorithm, the quantum computer evaluates the decoherence functional (with exponential speedup in both the number of qubits and the number of times in the history), and a classical optimizer adjusts the history parameters to improve consistency. We implement our algorithm on a cloud quantum computer to find consistent histories for a spin in a magnetic field, and on a simulator to observe the emergence of classicality for a chiral molecule.

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Physics

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PUBLICATIONS

WEAK VALUES OBTAINED IN MATTER-WAVE INTERFEROMETRY

Physical Review A 92

Weak values of the spin operator Sz of massive particles, more precisely neutrons, have been experimentally determined by applying a novel measurement scheme. This is achieved by coupling the neutron's spin weakly to its spatial degree of freedom in a single-neutron interferometer setup. The real and imaginary parts as well as the modulus of the weak value are obtained by a systematical variation of pre- and post-selected ensembles, which enables to study the complex properties of spin weak values.

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FIELD OF SCIENCE
Physics

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PUBLICATIONS

WEAK VALUES OF MOMENTUM OF THE ELECTROMAGNETIC FIELD: AVERAGE MOMENTUM FLOW LINES, NOT PHOTON TRAJECTORIES

arXiv

In a recent paper Mahler et al. have argued that the experi- ments of Kocsis et al. provide experimental evidence for Bohmian mechanics. Unfortunately these experiments used relativistic, zero rest mass photons whereas Bohmian mechanics is based on non-relativistic Schr¨odinger particles having non-zero rest mass. The experimental results can be accounted for in terms of a different approach based on the electromagnetic field that was already outlined by Bohm in an appendix of the second of his 1952 papers.

A subsequent develop- ment of this approach by Bohm, Hiley, Holland, Kaloyerou, Lam and Dewdney, shows in detail how this theory accounts for experimental quantum phenomena in general. Using this theory, we are led to the conclusion that the experiments have constructed mean momentum flow lines by measuring the real part of what we term the weak Poynt- ing vector. These results support and clarify the analysis of Bliokh et al.

The experimental flow lines can be constructed independently of the number of photons in the beam leading to the conclusion that flow lines cannot be interpreted as 'photon trajectories'. We discuss exactly how the notion of a photon arises in the field approach in the light of weak values.

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FIELD OF SCIENCE
Physics

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PUBLICATIONS

WEAK VALUES OF SPIN AND MOMENTUM IN ATOMIC SYSTEMS

Proceedings of: 'APS Division of Atomic, Molecular and Optical Physics Meeting Abstracts'.

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FIELD OF SCIENCE
Physics

Weak values have a long history and were first considered by Landau and London in connection with superfluids. Hirschfelder called them sub-observables and Dirac anticipatied them when discussing non-commutative geometry in quantum mechanics. The idea of a weak value has returned to prominence due to Aharonov, Albert and Vaidman showing how they can be measured. They are not eigenvalues of the system and can not be measured by a collapse of the wave function with the traditional Von Neumann (strong) measurement which is a single stage process. In contrast the weak measurement process has three stages; preselection, weak stage and finally a post selection. Although weak values have been observed using photons and neutrons, we are building two experiments to observe weak values of spin and momentum in atomic systems. For spin we are following the method outlined by Duck et al which is a variant on the original Stern-Gerlach experiment using a metastable, 23S1 , form of helium. For momentum we are using a method similar to that used by Kocsis with excited argon atoms in the 3P2 state, passing through a 2-slit interferometer.

The article was published in: Proceedings of: 'APS Division of Atomic, Molecular and Optical Physics Meeting Abstracts'.

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PUBLICATIONS

WEAK-VALUE AMPLIFICATION AND OPTIMAL PARAMETER ESTIMATION IN THE PRESENCE OF CORRELATED NOISE

Physics Revue

We analytically and numerically investigate the performance of weak-value amplification (WVA) and related parameter estimation methods in the presence of temporally correlated noise. WVA is a special instance of a general measurement strategy that involves sorting data into separate subsets based on the outcome of a second "partitioning" measurement. Using a simplified noise model that can be analyzed exactly together with optimal statistical estimators, we compare WVA to a conventional measurement method.

We find that introducing WVA indeed yields a much lower variance of the parameter of interest than does the conventional technique, optimized in the absence of any partitioning measurements. In contrast, a statistically optimal analysis that employs partitioning measurements, incorporating all partitioned results and their known correlations, is found to yield an improvement – typically slight – over the noise reduction achieved by WVA. This is because the simple WVA technique is not tailored to a given noise environment and therefore does not make use of correlations between the different partitions.

We also compare WVA to traditional background subtraction, a familiar technique where measurement outcomes are partitioned to eliminate unknown offsets or errors in calibration. Surprisingly, in our model background subtraction turns out to be a special case of the optimal partitioning approach in the balanced case, possessing a similar typically slight advantage over WVA. These results give deeper insight into the role of partitioning measurements, with or without post-selection, in enhancing measurement precision, which some have found puzzling. They also resolve previously made conflicting claims about the usefulness of weak value amplification to precision measurement. We finish by presenting numerical results to model a more realistic laboratory situation of time-decaying correlations, showing our conclusions hold for a wide range of statistical models.

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Full article

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FIELD OF SCIENCE
Physics

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PUBLICATIONS

WEAK-VALUE AMPLIFICATION OF THE NONLINEAR EFFECT OF A SINGLE PHOTON

Nature Physics 13

In quantum mechanics, the concept of weak measurements allows for the description of a quantum system both in terms of the initial preparation and the final state (post-selection)1. This paradigm has been extensively studied theoretically and experimentally, but almost all of weak-measurement experiments carried out to date can be understood in terms of the classical (electromagnetic wave) theory of optics.

Here, we present a quantum version in which the measurement apparatus deterministically entangles two distinct optical beams. We show that a single photon, when properly post-selected, can have an effect equal to that of eight photons: that is, in a system where a single photon has been calibrated to write a nonlinear phase shift of φo on a probe beam, we measure phase shifts as large as 8φo for appropriately post-selected single photons.

This opens up a new regime for the study of entanglement of optical beams, as well as further investigations of the power of weak-value amplification for the measurement of small quantities.

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Full article

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FIELD OF SCIENCE
Physics

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PUBLICATIONS

WHAT CONSTITUTES EMERGENT QUANTUM REALITY? A COMPLEX SYSTEM EXPLORATION FROM ENTROPIC GRAVITY AND THE UNIVERSAL CONSTANTS

Entropy 20(5)

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Physics

In this work, it is acknowledged that important attempts to devise an emergent quantum (gravity) theory require space-time to be discretized at the Planck scale. It is therefore conjectured that reality is identical to a sub-quantum dynamics of ontological micro-constituents that are connected by a single interaction law. To arrive at a complex system-based toy-model identification of these micro-constituents, two strategies are combined.

First, by seeing gravity as an entropic phenomenon and generalizing the dimensional reduction of the associated holographic principle, the universal constants of free space are related to assumed attributes of the micro-constituents.

Second, as the effective field dynamics of the micro-constituents must eventually obey Einstein's field equations, a sub-quantum interaction law is derived from a solution of these equations. A Planck-scale origin for thermodynamic black hole characteristics and novel views on entropic gravity theory result from this approach, which eventually provides a different view on quantum gravity and its unification with the fundamental forces.

The article was published in: Entropy 20(5): 335.

Full article

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PUBLICATIONS

WHEN PHOTONS ARE LYING ABOUT WHERE THEY HAVE BEEN

Entropy 20(7)

The past of the photon in a nested Mach-Zehnder interferometer with an inserted Dove prism is analyzed. It is argued that the Dove prism does not change the past of the photon. Alonso and Jordan correctly point out that an experiment by Danan et al. demonstrating the past of the photon in nested interferometer will show different results when the Dove prism is inserted.

The reason, however, is not that the past is changed, but that the experimental demonstration becomes incorrect. The explanation of a signal from the place in which the photon was (almost) not present is given. Bohmian trajectory of the photon is specified.

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FIELD OF SCIENCE
Physics

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PUBLICATIONS

WHERE IS QUANTUM THEORY HEADED?

arXiv

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2014

FIELD OF SCIENCE
Physics

The organizers have asked me to state my views on the direction of the fu- ture development of quantum mechanics. Will it evolve within the standard framework, without the addition of new foundational physics? Or will the foundations require modification in an, at least in principle, experimentally detectable way?
The article was published in: arXiv preprint arXiv:1401.0896.

Full article

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